UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

BERKELEY, CALIFORNIA

CALIFORNIA WHITE WHEATS

BY

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BULLETIN No. 212

April, 1911

SACRAMENTO

W. W. SHANNON - - - - SUPERINTENDENT STATE PRINTING

1911

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CALIFORNIA WHITE WHEATS.

KINDS OF WHEAT.

NOTE.—The major part of this bulletin is the result of work done by Mr. A. J. Gaumnitz as a candidate for the degree of M.S. To the data so secured has been added other data which seemed to be closely related. Credit should particularly be given to Messrs. B. R. Jacobs, and E. J. Lea, for portions of the routine chemical work, and to Miss Edith Miller for the microscopic measurements.

At present agriculturists quite generally recognize eight species of the genus *Triticum,* as follows: *Triticum vulgare, Triticum compactum, Triticum turgidum, Triticum durum, Triticum polonicum, Triticum spelta, Triticum dicoccum,* and *Triticum monococcum.* The last three species named are of little value in this country directly, and become important only in so far as they are used in improving the commonly produced varieties by methods of breeding. Emmer and speltz are grown in considerable quantities in Russia, Germany, France, Spain, Italy and Servia, and the monococcum (einkorn or engrain) in the same countries, but to a lesser extent. Speltz is used mainly as cattle food. Emmer and monococcum are used as a human food to a limited extent.

Though the botanic characteristics of the Poulard, Polish and Durum types are quite distinct in kernels and other parts, their adaptation and uses are very similar. They are quite rank, hardy growers, and suited to the semi-arid regions. The Durums are well adapted for the production of macaroni.

Durum flour when blended with that of the common bread wheats, produces a bread which compares not at all unfavorably with that from ordinary flours. These wheats possibly may be used for blending to improve the common wheats, and especially California white wheats, for they are relatively high in gluten. From a field standpoint they are fairly rust resistant, are able to subsist on a minimum of moisture and at the same time withstand quite high temperatures.

The common bread wheats (*Tr. vulgare*) are a quite variable species and are the most extensively grown of any in the United States. They have been known especially for their bread-flour producing qualities, but setting aside prejudice it is questionable whether they should longer hold that title to the exclusion of the best durum varieties. There is a considerable difference in the bread-making qualities of the different varieties of the common wheats, and when the durum wheats of good

quality are ground into flour and baked, in comparison with the bread wheats, it is readily seen that in flour-yielding power, color and lightness of the loaf produced, they compare very favorably.

The hard wheat area is being rapidly extended northward into Alberta and adjacent provinces. This class of wheat is what the Minneapolis mills grind into their world-famed flours. Although some Kan-

Bearded type of common wheat. Beardless type of common wheat. A Durum wheat.

FIG. 1.—Showing typical wheat heads. One half natural size.

sas hard wheat is also used, they depend largely upon the northern hard wheat for the quality of their flour.

In contradistinction to the hard wheats, we may note the white (or soft) wheats of the central and Pacific coast region. These wheats are also spoken of as bread wheats, but they differ as widely from the hard winter wheats grown in the north central states as do the durum

wheats, so that for technical study at least they deserve separation and distinction.

These wheats, as indicated by the name, are very light colored as compared with eastern wheats; and further, they produce a very white flour. Some of these flours are nearly dead white, having practically no color value at all. Some samples have so little yellow that the lightest tinted yellow glass of the Lovibond tintometer is too yellow to match the flour. The Sonora variety, however, yields flour that has even more of the yellow color than the average eastern flour.

FIG. 2.—Showing types of common bread wheats. One half natural size.

The wheats most widely grown in California are Little Club (commonly called Salt Lake Club), White Australian, Washington Bluestem, Sonora, and Propo.* There are a few other varieties scattered here and there in the State, but the above-named varieties are the only ones which can be said to have a wide favor with farmers in the large wheat-growing areas at the present time. Those of lesser importance are Golden Gate Club, Defiance, and White Chili.

*NOTE.—This wheat is sometimes called "Proper" instead of Propo.

At this date it is impossible to obtain any very accurate information as to when these wheats were introduced into the State, but doubtless most of them came from Australia. This is certainly true of White Australian and probably of Sonora, although the latter may have come by the way of Mexico. Of the former, Mr. G. W. McNear writes that it was imported from South Australia in the early sixties. It is even now grown there under the name of White Lammas.

Sonora is also grown extensively in Australia under the name "Velvet Pearl." Washington Bluestem is a strain very closely related to White Australian, and is probably an Australian importation corresponding to the variety now grown there under the name of Purple Straw. White Chili was imported in the early fifties, and if not the same, is very closely allied to Oregon Big Club. Of Propo, Mr. R. M. Shackleford, of Paso Robles, for many years connected with the milling trade of this State, is authority for the statement that this variety was a field selection from a sowing made from a shipment of wheat from Chili; the selection being sufficient in quantity to seed thirty acres of land in the Panoche Valley. From this thirty acres there was produced about five hundred sacks of wheat. Mr. Shackleford writes:

"I purchased this wheat and shipped it to Mr. A. D. Starr, of Marysville. The name given to this wheat at the time I purchased it was 'Snowflake,' and I shipped it to him under that name. There was some little seed left in the country, and quite an inquiry arose for the same seed. Mr. Starr returned me two car loads—one in the Salinas Valley, and one to Hollister. He reported to me the proper name was Propo. My memory is that was the name that was given to it at the time I purchased it, but old settlers tell me it was called 'Snowflake,' and that until it was returned from the north it was not known as 'Propo.' This leads me to believe that some of the original seed was distributed in the north and raised much as it was in San Benito County, and that it received the name Propo or Proper from the party who there grew it. My opinion is that this is a complete history of the introduction of Propo wheat into California."

The wheat was at one time held in high esteem both by farmers and millers. The latter still regard it highly as compared with the other California varieties, but growers have gradually drifted to one or another of those mentioned previously as giving greater returns in yield in the interior valleys. In the coast sections, however, Propo still holds its own and constitutes the bulk of the wheat there produced.

FIG. 4.—Showing relative per cent of various sizes in a typical White Australian wheat. The figures at the top indicate the size of mesh in millimeters of the screen used to separate each lot; the figures at the bottom express the percentage of the whole in each pile.

FIELD CHARACTERISTICS.

WHITE AUSTRALIAN.

This is a free-stooling, prolific, hardy, late, mid-season wheat. It is quite subject to rust attacks, and has only a medium tenacity. It is not well adapted to the coast sections on account of its liability to rust.

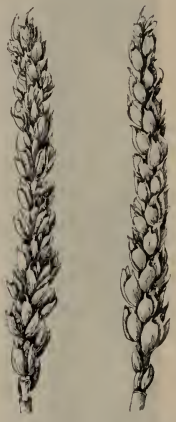


FIG. 3.—White Australian wheat.

CHARACTERISTICS OF GROWTH.

Stools: Fairly abundant, spreading, rather creeping.

Straw: White, strong, supple, rather tall.

Foliage: Good color, abundant, drooping, slightly glaucous.

Heads: Bald, smooth, long, regular, somewhat open, rather slender, tapering.

Spikelets: Narrow, two to three grained, not close.

Grain: Large, long, plump, white, soft, opaque, starchy interior. The grain is of pleasing appearance and generally of good bushel weight.

A typical White Australian should grade about as follows (Fig. 4):

FIG. 6.—Showing relative per cent of grains of various sizes in a sample of typical Little Club wheat. The figures at the top indicate the size of mesh in millimeters of the screen used to separate each lot; the figures at the bottom express the percentage of the whole in each pile.

LITTLE (SALT LAKE) CLUB.

FIG. 5.—Little Club. One half size.

This is a strong-growing, medium-stooling, hardy, mid-season wheat. It is very subject to rust attack. The chaff has a very high tenacity, this being one of the particular points in its favor in the interior valleys where the winds are strong. It ripens a little earlier than White Australian and is somewhat more prolific.

CHARACTERISTICS OF GROWTH.

Stools: Few and erect, strong-growing.

Straw: White, strong and of medium height.

Foliage: Good color, fairly abundant, upright and smooth.

Heads: Awnless, smooth, short, flat, compact; chaff yellow and tenacity high.

Spikelets: Wide, 2-5 grained, close.

Grain: Medium large, short, white, irregular in shape, very soft and starchy interior. The grain has a flat side which makes it apparently larger than is really the case.

A good type of the Little Club should have about the following grade (Fig. 6) based upon the method of grading by sieves as set forth in Bulletin 181 of this station.

SONORA.

FIG. 7.—Sonora wheat. One half size.

This is a light-stooling, rapid-growing, early wheat. It is much subject to rust, hence only adapted to the interior valleys. Its leaves are narrow and thin, and well adapted to withstand considerable drought. For this reason it has been the variety which has held its own in those portions of the State most subject to drought, namely in the southern portion of the San Joaquin Valley.

CHARACTERISTICS OF GROWTH.

Stools: Few and erect with medium growth.

Foliage: Light color, not abundant, texture thin, surface rough.

Heads: Long, medium thick, somewhat flat, compact, hairy and awnless.

Spikelets: Three-grained.

Grain: Short, round, plump, white, starchy interior. It is of unusually pleasing appearance and of good bushel weight.

The grading of a good sample of Sonora showed as follows (Fig. 8):

FIG. 8.—Showing relative per cent of various sizes of kernels in a typical Sonora wheat. The figures at the top indicate the size of mesh in millimeters of the screen used to separate each lot; the figures at the bottom express the percentage of the whole in each pile.

FIG. 9.—Propo wheat. One half size.

PROPO.

This is a fair-stooling, medium early, vigorous growing, bearded variety. Its yielding capacity is unusually good where winds are not too severe. The texture of the leaf is rather thin, thus enabling it to withstand rather severe drought.

CHARACTERISTICS OF GROWTH.

Stools: Fairly abundant, slightly spreading.

Straw: Purplish white, medium strong, good height.

Foliage: Dark green, drooping, only fairly abundant, slightly rough.

Heads: Bearded, smooth, long, open, medium slender, tapering.

Spikelets: Medium wide, open, three grained.

The relative percentage distribution of these several sorts of wheat in the State is shown in the following table, taking the points named as centers, the figures given being the results of estimates of a large number of buyers in the several regions.

TABLE I.—SHOWING COMPARATIVE DISTRIBUTION OF VARIETIES OF WHITE WHEAT IN CALIFORNIA.

Tributary to	Little Club	White Australian	Bluestem	Chili	Sonora	Propo
Visalia	5	30	0	0	60	5
Fresno	0	30	10	5	50	5
Madera	5	70	10	10	2	3
Modesto	0	60	40	0	0	0
Stockton	30	50	15	5	0	0
Sacramento	50	20	10	10	10	0
Woodland	90	0	10	0	0	0
Marysville	20	30	20	30	0	0
Chico	85	5	10	0	0	0
Salinas	0	15	0	0	0	85
Paso Robles	0	50	0	0	10	40

These estimates show that the Little Club is the favorite variety in the northern portion of the Sacramento Valley, that it declines rapidly in popularity as one goes southward and can hardly be called popular south of the country tributary to Stockton. In the coast section it is not grown at all. White Australian seems to have a more widely distributed popularity than any of the other sorts. It has its widest use in the middle San Joaquin section and the uplands of the coast region.

Washington Bluestem has come into wide favor during the last few years in the middle San Joaquin section and its use is extending northward in the Sacramento section. This wheat has all the characteristics of the White Australian, and it is very questionable as to its being at all different.

White Chili can be said to be popular only in the section about Marysville, although it has a scattered use extending even as far south as Fresno.

Sonora is in wide use only in the southern portion of the San Joaquin Valley, where its marked drought-resistant qualities have doubtless made it a "survival of the fittest."

Propo, although widely grown some twenty-five years ago in the Sacramento Valley, has been superseded entirely by other wheat. It is grown to a considerable extent now only in the coast section, especially about Paso Robles. This wheat was, and still is, held in high esteem by the milling trade.

FIG. 10. White Chili. One half size.

IMPURITIES.

Before conducting the following tests the samples selected were subjected to cleaning for the removal of the weed seeds present. The nature of foreign seeds found during this work is shown in the following table:

TABLE II.—SHOWING WEEDS FOUND

Number of Sample.	44.	62.	67.	73.	80.	81.	204.
1. *Agrostemma githago.* Corn cockle							
2. *Amsinckia intermedia.* Burweed, fire-weed					3	50	
3. *Anthemis cotula.* Mayweed, dog-fennel							10
4. *Avena fatua.* Wild oats							1
5. *Avena sativa.* Cultivated oats	59	1	22	12	22		
6. *Bromus maximus.* Broncho grass							
7. *Centaurea.* Star thistle (small flower)							
8. *Convolvulus.* Bindweed, morning-glory							
9. *Gilia* (tiny seeds)							
10. *Gnaphalium.* Cudweed, everlasting (infinitesimal seed)							
11. *Hemizonia.* Tarweed						9	
12. *Hordeum vulgare.* Cultivated barley	33	17	256	204	2	6	10
13. *Leptocaulis* (parsley family)							
14. *Lolium perenne.* Rye grass		1					
15. *Lolium temulentum.* Poison darnel; poison rye grass	15		3	25	48		17
17. *Phalaris paradoxa.* Gnawed canary grass							
18. *Medicago denticulator.* Burr clover							2
19. *Raphanus sativus.* Wild radish							
20. *Heliotropium currassavicum.* Wild heliotrope			20				
21. *Rumex crispus.* Curly dock							
22. Vetch							1
23. Smut wheat	3	20	15	12	8	20	
24. Number of foreign seeds	107	19	301	241	75	65	40
25. Percentage of impurities (foreign seeds)	3.7	9	23	13	2.6	2.2	7.5

The table is of interest particularly in showing, not only the extreme
more especially because *all of these wheats were actually being used by*
being the case, there is abundant reason for the extreme weediness of the
of the combined harvester to scatter weed seeds in the fields.

IN SEED WHEAT SAMPLES.

206.	208.	211.	229.	255.	276.	279.	284.	289.	296.	300.	306.	314.	320.	325.	208.
------	1	------	------	------	------	------	------	------	------	------	------	------	------	------	2
------	7	3	------	------	------	------	------	------	------	------	------	36	8	------	------
------	------	72	------	------	------	------	------	------	------	66	------	120	------	------	150
1	1	13	8	66	1	5	13	17	3	2	------	------	------	1	------
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
------	1	------	------	------	------	------	------	------	------	------	6	14	------	------	1
------	1	34	------	------	------	------	------	------	------	------	------	------	------	------	2
1	------	------	------	------	------	2	------	------	------	------	------	------	------	------	------
------	------	------	------	------	------	------	------	------	------	------	------	------	21	------	------
------	------	------	------	------	------	------	------	------	------	------	------	50	------	------	------
------	------	------	------	------	------	------	------	------	------	------	5	2	80	------	2
5	------	14	3	17	------	------	1	4	2	------	6	------	------	1	1
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	13
------	34	------	------	------	------	------	------	------	------	------	------	------	------	------	30
3	80	121	6	17	508	56	6	18	11	------	4	------	------	------	122
------	------	------	------	------	6	3	------	------	------	------	------	------	------	------	------
------	------	10	------	------	------	------	------	------	------	------	------	------	------	------	------
------	------	------	------	------	2	------	------	------	------	------	------	------	------	------	------
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	1
------	------	------	------	------	------	3	------	------	------	------	------	------	------	------	1
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
------	1	------	1	------	------	------	------	14	2	------	------	------	4	6	2
11	125	257	16	100	517	69	20	39	16	70	21	222	109	2	323
3.1	26.2	31.0	2.7	5.8	36.7	6.2	2.7	5.3	2.0	17.7	1.3	14.0	10.4	.15	29.4

weediness of the field on which most of these wheats were grown, but *farmers for seeding purposes in the condition here represented.* This fields in the wheat-growing areas of the State, aside from the tendency

PHYSICAL CHARACTERISTICS OF WHEAT.

The physical character of wheat has been the basis of much study, and certain chemical properties have been shown to be closely associated with well-defined physical characters. The milling qualities of wheats have also been found to be more or less closely associated with certain physical features, especially size of grain, hardness, thickness of bran, and bushel weight.

In Bulletin 181 of this station is discussed in detail the matter of size of kernel of a large number of samples of seed wheat collected from farmers.

The relative size of kernels of different kinds of wheat is determined by the use of a series of sieves, by weighing a definite and considerable number, or, what amounts to the same thing, counting the number in a certain weight, or by taking the weight per bushel. No one method can be relied upon altogether, because of the variation in the specific gravity; difference in maturity, causing the grain to be misshapen; and difference in normal shape of the kernels. In a general way, these differences are equalized and eliminated, by taking well-matured grain and depending not upon individual determination but upon several determinations and averages from these.

There is no recognized standard to represent the different sizes of grain, but after considerable study of the range of variation in the grains of wheat, the following meshes have been adopted as suited to the conditions of this study:

Size.	1	2	3	4	5	6
Mesh diam.	3.25 mm.	3.00 mm.	2.75 mm.	2.50 mm.	2.25 mm.	2.00 mm.

FIG. 11.—Showing actual size of grain separated by each sieve.

The common method of the grading of wheat is by separation of the grains according to size. This is most conveniently done by means of sieves. The grains in a given sample vary in size. If the sample be passed through a sieve having a mesh sufficiently large to retain only the very largest grains, and then successively through sieves with smaller and smaller meshes, until no more grains will pass through, the sample will have been *graded,* that is, each lot or pile of wheat will consist of grains of a definite size.

The character of the mesh has much to do with a proper grading by this method. The shape of the wheat-grain is such that a slit is required for the openings in the sieves in order to allow the passage of the grain. An examination of the wheat-grains will show that the two transverse diameters are not of the same size, and this must be regarded as having reference to the shortest diameter in each case. This difference in transverse diameter of grain is easily observed in Fig. 11.

The separations were in each case made upon samples consisting of plump grains. The grain represents the crops of three consecutive years extending from 1904 to 1906 inclusive.

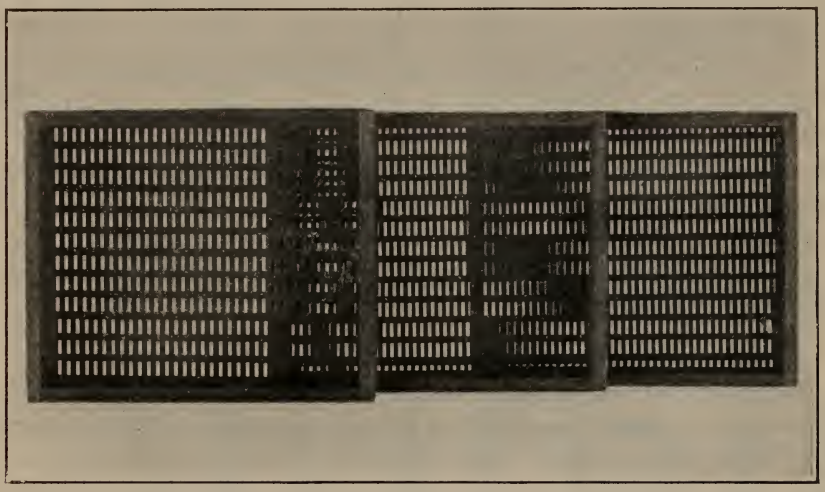


FIG. 12.—Showing the style of sieve used in the separation of the different sizes of kernels.

The several types enumerated above, when separated by means of the sieves here described, gave the following results:

TABLE III.—SHOWING MEAN RELATIVE SIZE OF GRAINS OF COMMON CALIFORNIA WHEAT.

	No. of sample.	Size 1. 3.25 mm.	Size 2. 3.00 mm.	Size 3. 2.75 mm.	Size 4. 2.50 mm.	Size 5. 2.25 mm.	Size 6. 2.00 mm.
White Australian	43	11.62	10.51	24.71	44.69	7.01	1.64
Bluestem	32	12.84	11.63	25.32	40.56	7.17	2.40
Little Club	55	14.52	7.47	17.13	47.88	10.25	2.72
Sonora	11	1.84	2.53	14.08	57.10	20.80	3.69
Propo	7	8.56	9.05	17.68	53.60	9.96	1.19

The above table of grading shows certain characteristics of the grain which will also be observed upon studying the appearance of the grains from the different varieties as shown in the illustrations. In the first place the similarity of the grading of White Australian and Bluestem will be noted, which is in line with the statement made in an earlier paragraph, that these two varieties were very closely related, if they are not even the same variety passing under different names. White Australian carries 46.8 per cent. of its grains in the first three sizes while

49.7 of the grains of the Bluestem are carried in the same sizes, and further it will be noted that the distribution in the three sizes is also essentially the same. The Little Club variety is distinctly different from these types and also from those following, the grading giving one the idea that it is a small grain, whereas the appearance to the eye gives one the impression of a relatively large grain. This is doubtless due to the peculiar shape of the Club grain. It has one flat side which makes its transverse diameter really smaller than is apparent. Both the Propo and the Sonora appear from the grading to be small grains. This is actually true of the Sonora, but of the Propo this is only true of its transverse diameter, the grain being rather longer than that of the White Australian.

A circumstance shown by this table is the larger weights in per cent. retained on the 3.25 mm. than on the 3 mm. sieve in the first three cases. One would expect to find the relations which are shown by the Sonora and Propo. In an examination of individual determinations a considerable difference is found in favor of the 3.25 mm. sieve. The largest being 24.2 per cent. on the larger sieve to 11.8 per cent. on the next lower size, while below this the percentage increases to the maximum on the 2.5 mm. sieve.

RELATION OF SIZE OF KERNEL TO FLOUR YIELD.

This matter of size of grain has an important bearing upon the milling value of a wheat, especially as between samples of the same variety other things being equal. For instance, of two wheats otherwise of equal value for milling, the one whose grains are the larger will give the larger yield of flour. Millers pretty generally recognize this by screening out the smallest grains. This may also be shown by certain results obtained with the mill at this laboratory. Further, we might expect this *a priori*, because there is bound to be larger percentage of bran upon the smaller grains of the same variety.

The following table is intended to show this fact. Here is shown the average grading of a number of samples of grain, each of which has been milled so as to secure the total yield of flour after the same style of milling. For the sake of this comparison, the first three sizes are grouped together and the last three sizes together, and are arranged in order of relative size of grains, the total number of samples used (52) being separated into four groups of thirteen samples each for securing an average:

TABLE IV.—SHOWING THE RELATION OF SIZE OF GRAIN TO YIELD OF FLOUR.

No. of Samples Represented.	Sizes 1, 2, 3.	Sizes 4, 5, 6.	Total flour yield.
13	5.3	94.7	69.1
13	15.9	84.1	69.7
13	28.9	71.0	70.7
13	60.7	39.3	71.4

PHYSICAL CHARACTERISTICS.

Table V shows certain physical characteristics of the grains. In it is shown the relative size of the kernels as measured by the number in 10 grams, the average weight per kernel, the bushel weight, the hardness when tested under uniform conditions, and the grade as determined by sieves as described heretofore.

In Table VI is given a summary of four types, the grouping being in accordance with the number of grains per 10 grams, and subdivided into groups having a range of 50 kernels each. In each case the number of samples falling in each group is given. This is significant in establishing the relation between the four types, as to the relative number of samples from each type falling in the same group, which allows comparisons to be made between the different kinds of wheat of the same size grain.

TABLE V.—SHOWING AVERAGE WEIGHT AND HARDNESS OF CALIFORNIA WHITE WHEATS.

Bluestem.

Laboratory number.	No. of kernels in 10 grams.	Average weight per kernel.	Weight per bushel.	Number of unbroken grains under weight of					Total number of unbroken grains.*
				.75 lbs.	1.00 lbs.	1.25 lbs.	1.50 lbs.	1.75 lbs.	
64	225	.0444	62.	100	100	96	82	59	437
606	231	.0432	61.	99	98	94	94	60	445
118	237	.0421	62.75	100	100	91	75	42	408
17	242	.0413	61.	100	72	48	17	0	237
24	242	.0413	59.50	93	68	41	20	0	222
25	243	.0411	61.	99	54	32	8	0	193
152	245	.0408	00.	94	84	64	40	5	287
9	257	.0389	61.12	100	83	48	0	0	231
303	263	.0380	61.	100	100	84	58	25	367
121	267	.0374	62.	100	95	81	53	13	342
268	268	.0373	60.25	100	88	54	16	2	260
472	271	.0369	59.	100	99	79	60	15	353
15a	277	.0361	00.	100	89	66	36	0	291
10a	277	.0361	58.50	87	71	56	30	3	247
16	279	.0358	60.12	100	43	28	0	0	171
15	280	.0357	61.25	100	54	17	0	0	171
4	285	.0350	57.	100	47	20	0	0	167
14	287	.0348	61.	100	87	31	0	0	218
371	292	.0342	59.50	99	74	37	12	0	222
299	298	.0335	59.50	94	91	65	24	11	285
267	309	.0323	59.75	95	74	37	12	6	224
206	313	.0319	60.50	95	77	54	0	0	226
205	313	.0319	60.75	72	63	51	19	7	212
300	314	.0315	56.25	99	91	68	18	0	276
5	314	.0315	60.25	100	43	22	0	0	165
386	334	.0299	58.75	99	77	43	12	0	231
272	350	.0285	59.50	100	86	63	50	22	321
Average	278	.0363	60.125	97	78	54	36	20	267

*NOTE.—The figures in this column represent the sum of the figures in the preceding five columns.

TABLE V (CONTINUED).—SHOWING AVERAGE WEIGHT AND RELATIVE HARDNESS OF CALIFORNIA WHITE WHEATS.

Australian.

Laboratory number.	No. of kernels in 10 grams.	Average weight per kernel.	Weight per bushel.	Number of unbroken grains under weight of					Total number of unbroken grains.
				.75 lbs.	1.00 lbs.	1.25 lbs.	1.50 lbs.	1.75 lbs.	
452	216	.0462	59.5	100	99	84	77	35	395
26	237	.0421	60.5	100	99	90	84	61	434
67	240	.0416	62.75	100	98	88	61	54	401
73	249	.0401	63.12	100	100	90	61	24	375
416	255	.0392	58.25	100	98	88	83	50	419
127	256	.0390	61.75	100	91	37	4	0	232
605	256	.0390	62.	100	100	100	90	53	443
129	259	.0386	60.50	100	83	50	7	0	240
68	260	.0384	62.25	100	100	90	56	16	362
66	261	.0383	61.25	100	100	93	75	28	396
23	264	.0378	62.25	61	39	11	0	0	111
62	267	.0374	62.75	100	81	47	20	0	248
453	268	.0373	60.50	100	97	85	81	47	410
311	268	.0373	61.	100	98	91	34	0	323
231	272	.0367	63.	100	90	88	60	43	381
304	274	.0364	62.50	100	96	88	34	9	327
134	280	.0357	62.	95	54	23	0	0	172
288	281	.0355	62.50	100	96	86	56	27	365
232	288	.0347	59.50	95	86	77	28	3	289
69	293	.0341	60.25	100	95	61	22	10	278
138	298	.0335	00.	92	50	23	0	0	165
184	298	0.335	60.50	97	80	22	0	0	199
322	299	.0334	60.50	100	100	93	31	0	324
28	300	.0333	60.25	100	99	85	46	25	355
275	302	.0331	59.	98	79	45	13	6	241
22	306	.0326	60.50	100	99	85	46	25	355
141	316	.0316	00.	95	50	26	0	0	171
326	326	.0306	61.	96	87	72	24	14	293
309	330	.0303	59.50	95	92	80	63	19	349
312	330	.0303	58.	100	99	92	22	12	325
78	337	.0296	52.50	100	92	42	6	0	240
77	342	.0292	60.	100	95	58	11	0	264
319	369	.0271	59.50	100	84	43	0	0	227
310	375	.0266	57.50	100	66	18	0	0	184
359	443	.0225	53.	99	45	29	18	4	195
Average	292	.0341	60.29	97	86	65	43	26	299

TABLE V (CONTINUED).—SHOWING AVERAGE WEIGHT AND HARDNESS OF CALIFORNIA WHITE WHEATS.

Little Club.

Laboratory number.	No. of kernels in 10 grams.	Average weight per kernel.	Weight per bushel.	Number of unbroken grains under weight of					Total number of unbroken grains.
				.75 lbs.	1.00 lbs.	1.25 lbs.	1.50 lbs.	1.75 lbs.	
96	210	.0476	59.50	100	100	100	100	100	500
459	226	.0442	59.	100	97	96	91	83	467
441	235	.0425	61.50	100	100	99	95	94	488
443	236	.0425	62.50	100	100	98	96	90	484
436	243	.0411	62.12	100	99	99	97	82	477
446	243	.0411	63.	100	99	97	95	87	478
440	244	.0409	60.	100	100	100	96	86	482
439	247	.0404	61.	98	94	94	91	33	410
607	248	.0404	63.	100	100	98	85	53	436
449	252	.0396	60.	100	99	94	90	62	445
445	255	.0392	60.75	100	100	100	90	70	460
448	263	.0380	62.	100	100	99	91	79	469
124	271	.0369	62.	98	81	55	10	0	244
438	274	.0364	60.	100	100	97	87	59	443
130	282	.0354	60.25	100	80	45	10	0	235
444	285	.0349	63.	100	95	89	86	77	447
28a	286	.0349	00.	94	83	52	13	0	242
442	289	.0346	62.	100	100	97	96	86	479
6	292	.0342	61.25	100	92	67	13	0	272
144	306	.0326	60.	99	66	21	0	0	186
372	311	.0321	60.75	100	100	97	86	44	427
139	314	.0315	00.	95	76	34	6	0	211
128	315	.0317	59.	100	84	36	7	0	227
51	316	.0316	58.50	47	21	9	0	0	77
51a	317	.0316	58.50	47	21	9	0	0	77
266	317	.0316	60.75	99	76	39	0	0	214
315	330	.0303	59.	97	70	12	2	0	181
161	330	.0303	62.	100	92	57	20	6	275
8	332	.0301	60.	100	63	39	0	0	202
27	334	.0299	58.25	98	92	72	71	7	340
53	336	.0297	61.	100	93	58	23	7	281
143	337	.0296	00.	98	68	30	2	0	198
11	340	.0294	59.	100	43	31	0	0	174
59	342	.0292	60.50	100	92	64	29	4	289
80	355	.0281	60.	100	96	64	30	3	293
57	356	.0279	60.25	99	85	54	25	5	268
21	360	.0277	59.	94	35	27	25	0	181
56	363	.0275	60.50	99	88	47	17	5	246
49	363	.0275	60.	54	46	14	8	0	112
50a	363	.0275	58.50	23	0	0	0	0	23
50	363	.0275	59.50	23	0	0	0	0	23
58	366	.0273	60.50	100	97	63	23	3	286
277	367	.0272	57.75	100	60	29	0	0	189
253	373	.0268	59.	99	79	40	8	0	226
60	377	.0265	63.	72	43	24	10	3	152
305	377	.0265	59.50	78	66	41	20	0	205
54	390	.0256	61.12	100	92	58	24	8	282
55	390	.0256	59.	96	82	41	13	0	232
317	419	.0238	59.25	95	37	18	0	0	150
290	537	.0186	58.87	100	77	48	25	0	250
Average	323	.0325	60.33	92	80	60	48	47	288

TABLE V (CONTINUED).—SHOWING AVERAGE WEIGHT AND HARDNESS OF CALIFORNIA WHITE WHEATS.

Sonora.

Laboratory number.	No. of kernels in 10 grams.	Average weight per kernel.	Weight per bushel.	Number of unbroken grains under weight of					Total number of unbroken grains.
				.75 lbs.	1.00 lbs.	1.25 lbs.	1.50 lbs.	1.75 lbs.	
167	254	.0393	61.50	98	92	71	35	7	303
481	272	.0367	66.	100	100	100	99	80	479
245	276	.0362	64.75	100	100	93	77	34	404
74	296	.0337	65.	100	97	87	55	25	364
76	337	.0296	63.	100	100	94	66	32	392
33	356	.0280	64.25	100	96	87	73	52	408
63	359	.0278	64.	100	93	75	26	9	303
249	371	.0269	64.75	96	91	75	75	33	370
140	444	.0225	61.	100	70	29	4	0	203
137	457	.0218	63.50	97	65	24	0	0	186
257	518	.0193	60.25	94	68	42	17	0	221
Average	358	.0292	63.45	98	88	70	52	34	330

Propo.

Laboratory number.	No. of kernels in 10 grams.	Average weight per kernel.	Weight per bushel.	Number of unbroken grains under weight of					Total number of unbroken grains.
				.75 lbs.	1.00 lbs.	1.25 lbs.	1.50 lbs.	1.75 lbs.	
46	236	.0423	61.	100	100	89	53	27	369
45	270	.0370	60.25	100	76	55	40	17	288
47	322	.0310	63.50	100	92	78	34	7	311
79	341	.0293	62.75	100	94	52	14	0	260
Average	292	.0349	61.87	100	90	69	35	17	307

TABLE VI.—SHOWING PHYSICAL CHARACTERISTICS OF WHEATS BY GROUPS.

Bluestem.

Range of seeds per 10 grams.	Number of samples in group	Average number of kernels in 10 grams	Weight per bushel, pounds	Number of kernels unbroken under weight of						Sieve grading.	
				.75 lbs.	1.00 lbs.	1.25 lbs.	1.50 lbs.	1.75 lbs.	Total	Sizes 1, 2, 3	Sizes 1, 5, 6
200-250	7	238	61.2	98	82	66	48	27	318	68.3	31.7
251-300	13	277	60.0	98	78	51	22	5	256	54.4	45.6
301-350	7	321	59.4	94	73	48	16	5	236	35.2	64.8
Average	27	274	60.2	96	78	55	29	12	270	52.6	47.4

Australian.

200-250	4	234	61.5	100	99	88	71	43	401	65.5	34.5
251-300	19	274	61.3	97	86	66	36	15	300	50.3	49.7
301-350	9	321	58.8	98	88	65	28	12	291	31.8	68.2
351-400	3	396	56.6	100	65	30	6	1	202	10.4	89.6
Average	35	306	59.5	99	85	62	35	18	299	39.7	60.3

Little Club.

200-250	9	237	61.3	100	99	98	94	79	470	72.6	27.4
251-300	10	275	61.3	99	93	80	59	43	374	60.1	39.9
301-350	15	325	59.8	92	72	41	15	4	224	30.8	69.0
351-400	14	359	59.8	81	72	41	14	2	210	15.0	85.0
Average	48	299	60.5	93	84	65	46	32	319	48.1	51.9

Sonora.

200-250	4	275	64.3	100	97	88	67	37	389	35.7	64.3
251-300	1	337	63.0	100	100	94	66	32	393	10.4	89.6
301-350	3	362	64.3	99	93	79	58	31	360	12.9	87.1
351-400	1	444	61.0	100	70	29	4	0	203	0.0	100.0
401-450	1	457	63.5	97	65	24	0	0	186	1.6	98.4
451-500	1	518	60.3	94	68	42	17	0	221	2.5	97.5
Average	8	323	63.8	100	97	87	64	33	380	19.6	80.4

Grand Average.

200-250	25	246	62.1	99.5	94.2	85.0	70.0	47	395	60.5	39.5
251-300	40	314	61.4	98.5	89.2	72.7	45.7	25	306	43.8	56.2
301-350	34	332	60.4	96.2	81 5	58.2	28.5	2	266	27.7	72.3
351-400	18	399	59.1	93.6	69.0	33.6	8.0	1	205	8.5	91.5

The discussion of the results appearing in the tables of physical characteristics will be based upon the small tables of averages (Table VI)

in order to eliminate the influence of a number of apparently extreme variations which do not seem to be entirely consistent. In the case of Sonora wheat the groups 350–400, 400–450, 450–500 are also eliminated in making up the averages, inasmuch as but a single sample appears in each of these groups, and the previous table shows such a range between different samples that it is thought unsafe to base any statement upon these groups carrying but a single sample.

Relative Size of Varieties.—In this table the relative size of the several varieties is shown in two ways, namely, the average number of grains in 10 grams and the sieve gradings, sizes 1, 2, 3, being the larger-sized grains. Considering the varietal averages as shown in the table, it will be seen that as to size of kernel the varieties stand in the following order in both instances: Bluestem, Little Club, Australian, Sonora. A constant relation is seen to exist between the size of grain as shown in sieve grading, and the weight per bushel.

The table shows in every instance that the weight per bushel increases as the number of grains per 10 grams decreases, that is, as the size of the kernel decreases, the weight per bushel decreases, provided the type of grain remains the same, but if the type changes and the size of grain remains the same the weight per bushel may vary widely. As, for instance, the bushel weight of Bluestem and Little Club in the 251–300 group, with an average number of kernels per 10 grams respectively of 277 and 275, the Bluestem weighed but 60 pounds per bushel, while the Little Club showed 61.3, or a difference of over 2 per cent. *It would appear, then, that in the use of this factor in the judging of grains it should be applied only to lots of the same variety.*

Hardness of Kernels.—It is generally held that the hardness of a grain gives, in a rough way, its general adaptability for milling purposes, particularly if the test be applied within the variety. This test is usually given in the purchase of grain by the biting of several kernels, but it is very doubtful if an approximate idea of the relative hardness of kernels of the same variety can thus be established. As between durum varieties and the white wheats it would, of course, be possible to differentiate, and also between the darker-colored wheats of the middle west and white wheats of the west, but as between one lot of Australian and another the matter is very doubtful. Further, it has certainly not been demonstrated that this is a factor of importance. Nevertheless, an attempt was made to make a comparison of these common California sorts, in the matter of hardness, by some method approximating as nearly as possible the biting method, by means of mechanical means of such a nature as to measure the weight used in each case to break the grain, and in this manner establish a means of comparison in this respect.

The apparatus employed consisted of a pair of ordinary pincers, as shown in the illustration, mounted upon a suitable standard, with a weight attached to the upper arm by means of a wire. A number of more complicated arrangements were tried, but none seemed to give more uniform results than this simple contrivance. The tests were made with five different weights—0.75, 1.00, 1.25, 1.50, 1.75 pounds, respectively. One hundred grains were counted out for each weight, and the hardness obtained by opening the jaws of the pincers just wide enough to insert the grain between them, and then allowing the weight to settle gently. The grains remaining unbroken by each weight were set aside and counted. The work was done under as nearly uniform conditions as possible. The authors are inclined to doubt the fact that the hardness of the grain bears any very definite relation to the milling value. If such were the case, one would expect to find the varieties under such a test as this arranging themselves in nearly the same

FIG. 13.—Showing apparatus used in testing hardness of kernels.

order as the results obtained on the mill, and this can not be said to have been the case in the case of individual samples, although it must be admitted that the general trend of results points in that direction.

The facts which are evident from this trial are as follows; within the varieties individually the larger the grain the harder, which it will be noted is in the same direction as the flour yield. This appears to be true in each one of the varieties tested, without exception. Again, the greater the weight per bushel within the variety the harder the kernel. This, of course, means that the more dense the kernel the greater is its weight per bushel, other things being equal. Thus, between two lots of wheat of the same kind of different-sized kernels one would expect to find the larger-sized kernels harder, and it is quite evident that the larger-sized kernels will also give a greater flour yield. The quality of the flour, however, is quite apart from this general statement.

As between the varieties it is to be noted that the following order is shown; Sonora, Little Club, Australian, and Bluestem. This is quite a different order than would probably be assigned to these grains by a

miller, who would probably place them in the following order from a milling standpoint, Australian, Bluestem, Sonora, Little Club. There is little question but what the above-named figures represent the relative hardness of the varieties when expressed in actual weights, which would make it appear that the action under the rolls involves other factors besides the hardness, for it is the action under the rolls, which the miller has learned from long experience, which is likely to govern him very much when he attempts to judge of hardness by biting the grain; and the difference between the white wheats is so slight, that he is unconsciously influenced almost altogether by the results of his experience with the grains under the rolls, rather than by the real hardness of the kernel.

Indeed, one would expect the Sonora grains to be the harder from their general appearance, and from their usually higher bushel weight. The grains are small and dense, have a thin, smooth, glossy bran and more than make up in weight for what they lack in size, and this greater density is shown in their relative hardness as compared with the other varieties tested.

THICKNESS OF BRAN.

The thickness of the bran is recognized by millers as having more or less to do with the milling characteristics of wheats, and some preliminary work was undertaken in connection with these investigations towards a measurement of the thickness of the bran of the varieties of wheat under trial.

For this preliminary work ten typical heads of White Australian were selected for examination.

Answers to two questions were sought: First, is the thickness of the bran fairly uniform in the same kernel; second, is the thickness of the bran of kernels from different parts of the same head fairly uniform?

Preparation of the Grain.—To toughen the grain for section cutting it was first soaked in water, and then allowed to dry thoroughly on the slide. The section was cleared with clove oil, and to free the preparation from air bubbles the dry section was treated with alcohol just before treatment with clove oil.

The drawing was done by the aid of a camera lucida attachment to the microscope. An outline of the outer and inner edges of the bran was drawn, and the average width determined by measurement. Measurements were made at three points upon each grain on cross sections made at the ovary end of the kernel, at the center and at the beard end of the kernel, about 20 measurements being made upon the bran of each cross section.

In all 60 kernels were thus examined, 2 grains being taken from the top, 2 from the bottom and 2 from the center of each of the 10 heads.

Of these three fourths of the thickest sections were at the beard end of the kernels, but not much variation appeared from the center to the ovary end.

TABLE VII—SHOWING MEASUREMENTS OF THICKNESS OF BRAN IN TEN HEADS OF WHITE AUSTRALIAN WHEAT.

	A.			B.		
	Ovary end.	Middle.	Beard end.	Ovary end.	Middle.	Beard end.
Third kernel from top of head—						
1	2.8	3.3	3.4	2.5	2.4	3.4
2	3.4	3.1	3.6	2.9	2.4	3.3
Middle of head—						
1	3.7	2.7	3.6	2.7	3.6	4.0
2	3.8	3.1	3.2	3.3	2.8	3.0
Third kernel from bottom of head—						
1	3.1	3.4	3.5	2.9	3.1	3.5
2	3.1	3.4	3.8	3.0	2.8	3.5
	C.			D.		
Third kernel from top of head—						
1	3.0	2.9	3.6	2.4	2.8	2.8
2	3.5	3.1	2.8	2.7	2.6	2.9
Middle of head—						
1	2.7	3.1	3.4	2.7	3.1	3.5
2	2.6	2.9	3.8	3.3	2.9	2.7
Third kernel from bottom of head—						
1	3.0	3.9	2.9	2.7	3.3	3.5
2	3.1	3.0	3.6	2.8	2.7	2.9
	E.			F.		
Third kernel from top of head—						
1	2.6	2.8	2.7	2.9	2.8	3.7
2	2.6	3.1	2.7	2.7	2.6	3.3
Middle of head—						
1	2.6	3.0	3.6	3.2	3.3	3.3
2	2.4	2.9	3.1	3.0	3.1	3.8
Third kernel from bottom of head—						
1	2.5	3.3	3.5	2.9	3.7	3.3
2	2.7	3.2	3.5	2.5	2.9	3.1
	G.			H.		
Third kernel from top of head—						
1	3.0	2.7	3.2	3.3	2.8	3.3
2	2.9	2.5	3.7	2.6	2.4	3.2
Middle of head—						
1	3.3	3.8	4.0	3.5	3.4	3.9
2	3.3	3.2	3.7	3.0	3.0	3.5
Third kernel from bottom of head—						
1	3.0	3.0	3.5	2.9	3.3	3.6
2	3.1	3.0	3.8	3.7	3.4	3.3

TABLE VII—*Continued.*

	I.			J.		
	Ovary end.	Middle.	Beard end.	Ovary end.	Middle.	Beard end.
Third kernel from top of head—						
1	2.5	3.2	3.5	2.6	3.2	3.9
2	2.8	2.6	3.0	2.8	2.8	3.1
Middle of head—						
1	2.9	2.8	3.9	3.0	2.8	3.9
2	2.9	2.9	3.6	3.2	3.1	3.5
Third kernel from bottom of head—						
1	2.7	3.3	2.9	2.9	3.0	3.5
2	2.3	3.0	3.6	2.9	3.0	3.2

Collecting these results so as to show the variation a little more closely by averaging the measurements for each of the two grains from the several heads we have as follows:

Third Kernels from Top of Head.

Head.	A	B	C	D	E	F	G	H	I	J	Average.
Kernel No. 1	3.16	2.76	3.16	2.66	2.70	3.13	2.96	3.13	3.06	3.23	2.995
Kernel No. 2	3.33	2.86	3.13	2.73	2.80	2.86	3.03	2.73	2.80	2.90	2.917
Average	3.14	2.81	3.09	2.69	2.75	2.99	2.99	2.92	2.93	3.06	2.956

Middle Kernels.

Kernel No. 1	3.33	3.30	3.06	3.10	3.06	3.26	3.90	3.60	3.20	3.23	3.284
Kernel No. 2	3.33	3.03	3.10	2.96	2.80	3.30	3.40	3.16	3.13	3.26	3.147
Average	3.33	3.16	3.08	3.03	2.93	3.18	3.55	3.38	3.16	3.24	3.215

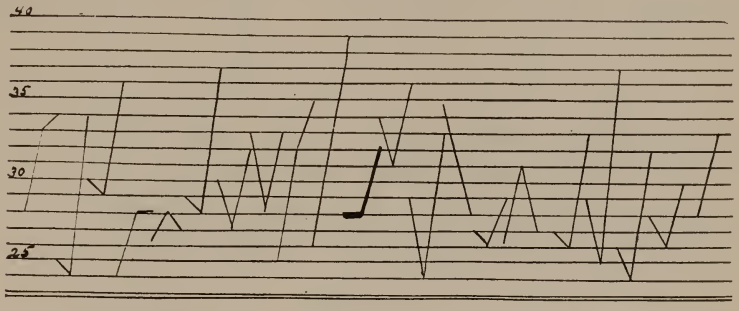
Third Kernel from Bottom of Head.

Kernel No. 1	3.33	3.10	3.26	3.16	3.10	3.30	3.16	3.26	2.96	3.13	3.176
Kernel No. 2	3.43	3.23	3.23	2.80	3.13	2.83	3.30	3.46	2.96	3.03	3.140
Average	3.38	3.16	3.19	2.32	3.11	3.06	3.23	3.36	2.96	3.08	3.158

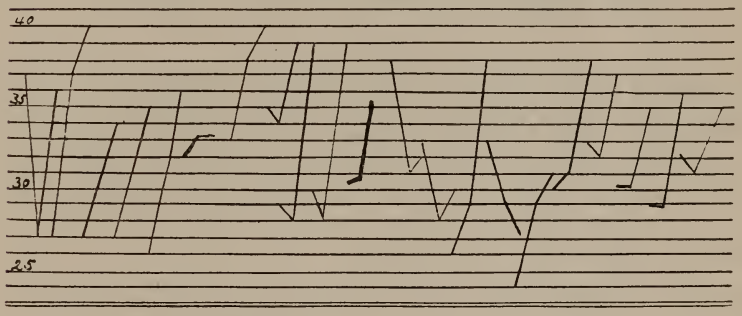
These figures indicate that there is considerable variation in the thickness of the bran on different parts of the same kernel, and that the bran from kernels on the center of the head is thicker than in kernels from either end.

Chart showing Thickness of Bran of White Australian Wheat.

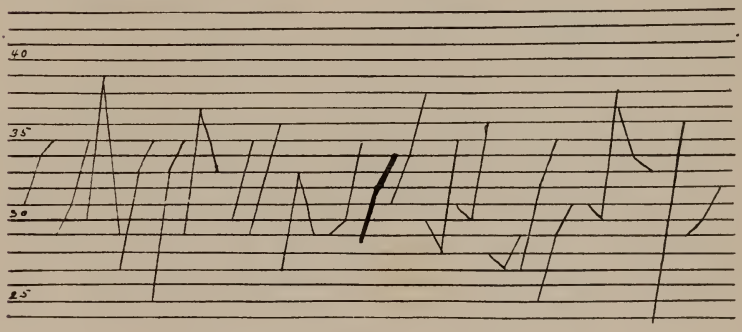
Third Kernel from Top of Spike



Middle Kernel



Third Kernel from Bottom of Spike.



Similar measurements were made in the case of Little Club, which gave the following average results:

	Ovary end.	Center.	Beard end.	Average.
Top of head	3.0 −	3.3 −	3.4 +	3.23
Middle of head	3.1 −	3.3 +	3.6	3.33
Bottom of head	3.1 −	3.3 −	3.5 +	3.30
Mean	3.06	3.30	3.50	3.29

Here again the same facts appear as in the case of White Australian, namely, as to the individual kernel, the bran was the thickest at the brush end; and with reference to the location on the spike, the thickest bran was found on the kernels from the middle of the head.

THE CHEMICAL COMPOSITION OF WHEATS.

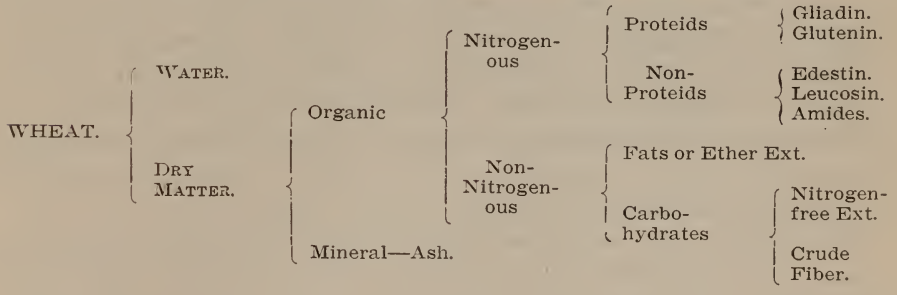
The question of the relation of the chemical composition of wheats to their baking or milling value has been one which has attracted the attention of chemists both in this country and abroad for many years, but up to the present time its complete solution has baffled their skill. While this is true, some advance has been made and certain factors which undoubtedly have a bearing upon their quality as related to baking have been determined; but, nevertheless, it must be admitted that we are still far from a very intimate understanding of the true relation of these factors. It is probably unnecessary to devote any space to a discussion of the real practical value which chemical data would have, provided they could be correlated on a correct basis with the baking value of wheat or flour.

It is not likely that they would have a very close relation to the milling value except as such value is related to the baking value, because the milling value *per se* may be quite independent of the baking value of the flour. The milling qualities of a wheat are almost entirely dependent upon the physical characteristics of the grain, while the baking characteristics of the flour are evidently quite closely related to certain chemical factors. The miller is primarily interested in a large yield of flour of good appearance, while the prime question with the baker is that the flour shall have a sufficient "strength" for his special purpose. A wheat may have excellent milling qualities and still yield a flour quite unsatisfactory to the consumer, and vice versa. The former condition is far too often the case with the California wheats,

and this was the basal reason for the inauguration of the cereal investigation in which this Station is now engaged.

It is quite obvious, then, that the term "strength" and "quality" are not interchangeable, but have quite distinct meanings. The former refers to something which is rather definite in nature, notwithstanding we have not as yet fully ascertained what are the factors which determine the so-called "strength." The "quality" of a flour depends much upon the purpose for which it is intended. It may be very high for pastry, but very poor for bread. A flour which has very high "strength" is usually of lower "quality" for pastry purposes than one of much lower strength. On the other hand, high "strength" is extremely desirable, and well-nigh essential, for the making of good light bread, or macaroni.

The general composition of wheats does not differ materially from that of other organic bodies, in that it is made up of several different groups of constituents, viz., moisture, ash, crude protein, fats, and carbohydrates. These are not distinct and separate compounds, but are groups of bodies having similar properties or food value within each group. Thus, for instance, the term carbohydrates is a general term, embracing a large number of substances, as sugars, starches, certain gums, etc., while protein is the name of a general class of bodies containing nitrogen as an essential ingredient, examples of which are albumin or the white of eggs, the lean meat of animal bodies, the gluten of flour, etc. The composition may be graphically represented as follows:



In all cases water is present. In many instances this is very evident, as in grass, beets, turnips, etc., while in other material it is not so evident, yet when they seem perfectly dry under ordinary conditions, there is from 5 to 10 per cent. moisture present. This water has no more food value than that taken from wells or streams. It is, however, a necessary constituent of organic material. Moisture is determined in the laboratory by heating the material for a long time at the temperature of boiling water.

After the moisture has been driven off there is left the *dry matter,* which is partly organic and partly mineral in its composition.

The mineral matter of plants is expressed by the term *ash*. It is the residue left after burning to perfect whiteness.

The organic matter embraces two well-marked classes, viz., those containing the element nitrogen, *nitrogenous*; and those which lack nitrogen, *non-nitrogenous*. Of all the material composing a foodstuff, the nitrogenous matter is the most important. It embraces both proteids and non-proteids, which, however, are not usually separated, but classed together as *protein*.

The nitrogenous compounds of wheat consist principally of proteids of which five have been recognized and described by Osborne and Voorhees as follows:

1. A globulin, soluble in saline solutions, and not coagulable at a temperature below 100° C. This constitutes 0.6–0.7 per cent. of the grain.

2. An albumin, coagulable at 52° C. It differs from animal albumin in several important particulars. It constitutes from 0.3–0.4 per cent. of the kernel.

3. A proteose, which is extracted from the wheat by dilute saline solutions after removing the globulin by dialysis and the albumin by coagulation. It constitutes 0.2–0.4 per cent of the kernel.

4. Gliadin, a proteid body soluble in dilute alcohol, and forming nearly one half of the total proteid matter of the kernel.

5. Glutenin, which is insoluble in water, dilute saline solutions, and dilute alcohol, and which, together with gliadin, forms nearly the entire proteid content of the wheat kernel.

Gluten.—Chemists divide the above indicated proteids into two general classes, viz., gluten and non-gluten proteids. Gluten is a mixture of gliadin and glutenin. It is the amount and quality of gluten which gives to flour ability to rise into a light and spongy loaf of bread. In the process of bread making, the carbonic acid gas liberated during the fermentation period is imprisoned by the sticky, elastic gluten, and as the gas expands, causes the bread to become porous.

Crude gluten can be obtained either from a wheat meal or flour by washing out the starch and water-soluble portions from a dough made by kneading the meal with water. In this condition it will carry about two thirds of its weight of water and certain impurities which are fairly constant in different samples. "A good gluten has a light yellow color, is tenacious and elastic, while poor gluten is dark in color, sticky but not elastic."*

As the gluten of wheat is that constituent which causes the flour to be strong, wheats to be of high baking quality should carry a high percentage of gluten. This high percentage of itself, however, is not sufficient, since it is found that *glutens differ much in quality,* some are tough and elastic and others not. Again the latter generally are able

* Hunt's Cereals in America, page 41.

to retain a very much smaller amount of water, resulting in a correspondingly less number of loaves per barrel of flour. *To be of high quality a gluten should be highly elastic.*

It has been claimed by some writers that the quality of a gluten is much dependent upon the proportion of the gliadin and the glutenin present. M. E. Fleurent, a French investigator, states that the most favorable ratio of gliadin to glutenin in flour is 75 to 25. Snyder, formerly of the Minnesota Experiment Station, states that 80 to 85 per cent of the total protein should be gluten, and of this the proportion of gliadin to glutenin should be 60 to 65 per cent.

Later work of Snyder, however, seems to cast some doubt as to the value of this matter of proportion of gliadin to glutenin, for, in 1905, a year later than the former statement, he writes: "As our work on this point extends over a number of years it appears that *it is more a question of total gliadin than the ratio of gliadin to glutenin.*" The results presented in the later pages of this bulletin seem to bear out this latter statement of Snyder and to cast grave doubt upon the possibility of correlating the gliadin-glutenin ratio closely with the bread-making value of a wheat or flour.

Fats.—Nearly all foodstuffs contain more or less *fat.* Here, again, the term is not used in as definite a sense as in ordinary language, but rather refers to a class of bodies which have a similar composition, and since they are determined by extraction with ether, many chemists prefer to use the name *Ether Extract.* It really denotes more than fat in the case of green foodstuffs, as the coloring matter and certain gums are extracted at the same time, but in grain the extract is nearly all fats and oils. These do not differ in any essential particular from the animal fats and oils, which all belong to a class of bodies known as glycerides. The fat of wheat is not a very important element in determining its value.

The *Carbohydrates* are usually separated into *Crude Fiber,* and another class called *Nitrogen-free Extract.* The former is the woody tissue of the plant, which remains after successive boilings with a weak acid and a weak alkali. It is found principally in the bran. Carefully conducted experiments show that even this woody fiber has a nutritive value, a small quantity usually being digested. Still the value of foodstuffs usually varies inversely as the amount of crude fiber present. The *Nitrogen-free Extract* is composed of a number of substances as starch, sugar, dextrin, and gums, grouped together because similar in composition.

Starch is the most important of the carbohydrates of wheat and constitutes from 64 to 70 per cent. of the kernel. It is, of course, of great importance as the principal foodstuff in bread. *Sugar* and *dextrin* are

other compounds which are present in wheats in quite small quantities. In sound wheat if sugar be present it should be in the form of cane sugar. Should, however, the sugar be in the form of maltose it would undoubtedly indicate a partial hydrolysis of starch and would be objectionable. The same may be said with regard to the presence of dextrin.

Incomplete as are the present laboratory methods, they still furnish results of considerable value in a broad classification of wheats and flours, even if failing to distinguish between two samples of approximately the same "strength."

With the idea of obtaining more information relative to the chemical characteristics of the common California white wheats, the samples discussed previously, as well as some others, were subjected to chemical analysis.

THE METHODS FOR CEREAL ANALYSIS.

The methods of analysis adopted for this work were adapted from those given in Bulletin 107, of the Bureau of Chemistry, United States Department of Agriculture, and the work of Teller, and are set forth below.

Moisture.—Dry 2 to 3 grams of the material for five hours at the temperature of boiling water. Use the aluminum moisture dishes provided for this purpose. (Note.—If fat is to be determined the dried material from the moisture determination can be used.)

Ash.—Char 2 grams of the material, if a wheat meal, or 3 grams if a flour, and burn to whiteness at the lowest possible red heat. If a white ash can not be obtained in this manner, exhaust the charred mass with water, collect the insoluble residue on a filter, burn, add this ash to the residue from the evaporation of the aqueous extract, and heat the whole to a low redness till the ash is white or nearly so. Great care has to be taken with these wheat products not to overheat at the start. It must under no circumstances be fused if phosphoric acid is to be determined in the ash, otherwise fusing is allowable, the loss being so small as to be negligible.*

* Leavitt & Le Clerc, "Loss of Phosphoric Acid in Ashing Cereals," Jour. Am. Chem. Soc., Vol. XXX, No. 3, p. 391.

SCHEME FOR NITROGEN DETERMINATION.

The basal scheme for nitrogen determination for various protein compounds is as follows:

Determine total nitrogen	x
Determine non-gluten nitrogen (= salt soluble N. — constant *)	y
Difference = gluten nitrogen	$= x - y$
Determine gliadin nitrogen (=alcohol soluble)†	z
Difference=glutenin nitrogen	$= (x-y) - z$

* Constant for soft wheat meals=.15.
Constant for durum wheat meals=.20.
Constant for flour=.22.

These constants represent the average amount of gliadin nitrogen that will be found in the salt solution.

† Strictly speaking, the gliadin nitrogen should be corrected for the amid nitrogen present, but for most practical purposes this may be neglected.

Detailed Outline of Methods.

Total Nitrogen—Gunning Method: In a digestion flask (Kjeldahl) place one gram of the material to be analyzed. Add 10 g. of powdered potassium sulfate and about 20 cc. of concentrated sulfuric acid. Digest as in the ordinary Kjeldahl process, starting with a comparatively low temperature and gradually increasing. Digest until the mixture is colorless. Do not add either potassium permanganate or potassium sulfid. Dilute, neutralize and distil as in Kjeldahl method. In neutralizing it is convenient to add a few drops of phenolpthalein to serve as an indicator.

Use 10 cc. n/4 hydrochloric acid, dilute with an equal volume of water for collecting the ammonia and distil off about three fourths of the contents of the distillation flask. Use n/10 ammonia for titrating back the acid, with cochineal as an indicator.

NOTE.—For further details see Official Method, Bul. 107, page 7.

(2) Total Proteids. Nitrogen determined as above x 5.68 = total proteids.

(3) *Gliadin.* Weigh out 2 gms. of flour into a small flask holding somewhat more than 100cc. Add 100 cc. of 70 per cent. alcohol and shake thoroughly for 15 minutes. Allow to stand 18 hours and filter into a Kjeldahl digestion flask with a short neck. Wash the residue with 100 cc. of 70 per cent. alcohol. Add to the total filtrate 10 cc. of concentrated sulfuric acid and distill off the excess of alcohol, continuing the distillation until fumes appear. Add 10 cc. more of concentrated sulfuric acid and finish the determination of nitrogen by the Gunning method. The *nitrogen* × *5.68 = proteid soluble in alcohol.*

With old and unsound flours a correction must be made for soluble amid bodies.

(4) *Non-Gluten Nitrogen.* Place 4 grams of the material in a 200 cc. flask. Add about 15 cc. of a 1 per cent. solution of sodium chlorid and shake thoroughly. To the resulting homogeneous mass, add enough of the same solution to make exactly 100 cc. of the salt solution as a total amount. Shake the contents of the flask in a shaker for 6 hours. After allowing it to stand over night to settle, filter off 50 cc. of the liquid through a 12½ cm. dry filter, pouring back the first portion of the filtrate until it filters clear and determine the nitrogen therein by the Gunning method. On collecting this 50 cc. with a few cubic centimeters of washings in a Kjeldahl flask and adding 20 cc. concentrated sulfuric acid, the water can readily be boiled off, especially if the flask be protected from the naked flame. When the acid ceases to foam it is cooled slightly, sulfate of potash added and the nitrogen determination completed in the usual way. After adding the sulfate of potash, the time required for the digestion is but a few minutes.

A small percentage of gliadin nitrogen will be included in the above determination. Experience has shown that this amounts to about .15 per cent. for white wheat meals and is quite constant. This factor (.15%) should be subtracted from the nitrogen per cent., as determined in the above procedure. For factors to use with other wheats see page 344. The difference is called *Non-gluten Nitrogen.* The protein corresponding to this nitrogen is calculated by multiplying by 5.68.

(5) *Glutenin.* For most purposes the difference between the gluten nitrogen and the gliadin nitrogen, as determined above, may be considered glutenin nitrogen. For more accurate work, however, the glutenin nitrogen may be determined as follows:

The residue from the gliadin determination is washed with 70 per cent. alcohol until the washings no longer react for proteids. Transfer it to a flask and add 200 cc. of a 5 per cent. solution of sodium chlorid to remove globulin and other proteids. After two hours extraction the residue is washed with distilled water and transferred to a flask, 250 cc. of a 2 per cent. solution of potassium hydroxid added and after 3 hours' extraction the solution is filtered and the nitrogen determined in 200 cc. of the filtrate in the usual way.

(6) *Amid Nitrogen.* From 100 cc. of the salt extract precipitate all the proteids by adding 10 cc. of a ten per cent. solution of phospho-wolframic acid, made by dissolving the pure solid in distilled water. (*Note.* In case of bran, it may be necessary to add more of the phospho-wolframic solution.) Allow to settle before filtering and determine the nitrogen in the clear filtrate. In order to secure a clear filtrate it will doubtless be necessary to allow the solution to stand over night in order to obtain a clear supernatant liquid. On collecting this (50 or 100 cc. with a few cubic centimeters of washings) in a Kjeldahl flask and adding 20 cc. of concentrated sulfuric acid the water can be readily boiled off, especially if the flask be protected with a thin sheet of asbestos. When the acid ceases to foam it is cooled slightly, sulfate of potash added and the nitrogen determination completed in the usual way. After adding the sulfate the time required for digestion is but a few minutes.

(7) *Edestin and Leucosin Nitrogen.* To 50 cc. of the clear salt extract, obtained as described above, add, in a 500 cc. Kjeldahl digestion flask, 250 cc. of pure 94 per cent. alcohol (188 per cent. proof, re-distilled). Mix thoroughly and allow to stand over night. Collect the precipitate on a filter (10 cm.) of good quality, return to the flask, and determine the nitrogen, making proper correction for nitrogen in the filter.

NOTE.—If desired these two proteids may be separated by coagulating the leucosin at 60°C. and precipitating the edestin by adding alcohol to 50 cc. of the clear filtrate as before. The nitrogen in each precipitate may then be determined.

(8) *Baker's Sponge Test.*—100 grams of flour are weighed into a wide porcelain dish or bowl. A part of the water (50 to 65 cc.) necessary to make a stiff dough is run in from a burette. In this is dissolved 5 g. of sugar and 5 g. of compressed yeast. The flour is then stirred in with steel spatula and more water added until dough of standard stiffness is obtained. Amount of water used for dough recorded.

The dough is now placed in tubes of about 4 inch diameter, graduated into cubic centimeters. These tubes are now set in water at 90°F. and the dough allowed to rise. It must be constantly watched until the maximum height is reached and the dough falls, when the time required to rise and the volume in cubic centimeter is recorded. This is repeated and the volume and time again recorded.

By dividing the volume of loaf, to which 100 grams of flour rises, by the percentage of gluten in the flour, the volume of loaf produced by each gram of gluten is found.

(9) *Acidity.*—In a porcelain casserole place 5 grams of flour, and gradually mix with about 50 cc. of distilled water freed from carbon dioxid by previous boiling. When a perfectly homogeneous mixture has been obtained add a few drops of phenolpthalein, and titrate with n/50 NaOH. It is unnecessary to filter previous to titration. Calculate results to sulfuric acid.

(10) *Wet Gluten.*—Weigh out 25 grams of the sample, moisten with 15 to 18 cubic centimeters of water, knead to a stiff dough. Work thoroughly so as to bring all gluten into active contact. Allow to stand for one hour. Holding the mass in the hand under a slow stream of cold water gently pull and knead at the same time until the starch and all soluble matters are washed out. It is well to conduct the work over a fine sieve to prevent the loss of small particles of gluten. Then place in cold water and allow to stand for one hour, finally remove from the water, knead well in the hands, frequently drying the hands upon a towel. During the kneading of the gluten, manipulate it in such a way as to ultimately bring all parts of the gluten on the outside. When all the free water has been removed, roll the mass into a ball and weigh either upon a counterpoised card or in a flat-bottom dish. Note should be made of the color and general stiffness as shown by the way it stands up upon the card. The stiffer the gluten the more globular the mass.

(11) *Dry Gluten.*—After weighing, introduce the ball of wet gluten into a drying oven at a temperature of boiling water and try to constant weight. The time required will be not less than fifteen hours, cool and weigh.

(12) *Water Capacity.*—The difference between wet and dry gluten equals the water holding power. Record this, as one part gluten holds x parts of water.

(13) *Ether Extract.*—(Fat) Extract from 2 to 3 grams of the substance used for the determination of moisture, with anhydrous alcohol-free ether for sixteen hours. Filter off the solid residue through a small filter paper into a tared flask. Distil off the ether, and dry the extract to constant weight. This work is most conveniently done in a small wide-mouthed Erlenmeyer flask.

Or, the residue can be collected in a tared Gooch filter, dried as in the moisture determination, and the loss in weight regarded as ether extract.

NOTE.—The ether used for this work must be strictly anhydrous. To prepare this, wash any of the commercial brands of ether with two or three successive portions of distilled water, and add solid caustic potash or soda until most of the water has been abstracted from the ether. The final traces of moisture can be removed by adding to the partially dried ether carefully cleaned metallic sodium, cut in small pieces, until no more hydrogen gas is evolved. The dehydrated ether should be kept over metallic sodium.

A TRIAL OF THE POLARISCOPIC METHOD FOR THE DETERMINATION OF GLIADIN.

The use of the polariscope has been suggested for the determination of gliadin in cereal products as offering a method which would reduce the time required by the ordinary Gunning-Kjeldahl operation. and at the same time be sufficiently accurate for technical purposes.

With the idea of satisfying ourselves upon the applicability of the method, as applied to the products in hand, comparative trials of this method were made against the ordinary Gunning-Kjeldahl procedure.

This is more rapid than the regular method and is recommended for general work when there is sufficient material. Weigh out 15.97 grams of the material and digest over night in 100 cc. 70 per cent alcohol.

The flask should be agitated thoroughly at intervals of one half-hour for a period of two hours. Filter to a clear solution, protecting from evaporation as much as possible. Polarize in a 220 mm. tube. The reading will probably be a minus one. Correct for sugar by adding to 50 cc. of the filtrate sufficient mercuric chlorid (concentrate solution) to precipitate all the proteids: Make to 55 and polarize again.

The range of material covered by these trials was somewhat different than those mentioned in the original article by Snyder.* The first series of analyses were made upon soft wheat meals. The results are set forth below:

Laboratory number.	Gliadin nitrogen calculated to dry matter.		
	By Polariscope method.	By Gunning method.	Difference.
19	0.72	--	--
249	0.56	0.54	+.02
254	0.46	0.49	−.03
257	0.38	4.40	−.02
265	0.42	0.43	−.01
266	0.42	0.44	−.02
268	0.39	0.39	.00
270	0.38	0.43	−.05
288	0.49	0.49	.00
290	0.57	0.64	−.07
313	0.39	0.55(?)	−.16
322	0.39	0.53(?)	−.14
326	0.49	0.50	−.11

The above determinations were made upon soft white wheat meals. In this lot of samples the gliadin determination by the Gunning method had already been made several weeks before the trial of the polariscope method.

Determinations were made by the polariscope method on the basis of the changed moisture content of the sample, and the results in each case calculated to dry matter for comparison. Further, the methods were

* H. Snyder in Jour. Am. Chem. Soc., Vol. XIX, No. 12.

operated by different parties. so there were undoubtedly introduced into the operation greater differences in the manipulation of securing solution of the gliadin than if the two operations had been conducted by the same person. Notwithstanding these sources of error it will be noted, that with the exception of Nos. 313 and 322, concerning which there was previously existing some doubt as to the accuracy of the original determination, the polariscopic method gave results which are within the range of error of most operations.

The above results not being quite satisfactory, the comparison of methods was carried further with the same class of material, the sample operated upon in the one method being taken from the same solution as in the other, one portion being used for polarization and another treated by the Gunning method. The solution of gliadin in these trials was effected by digesting in the cold, as described by Snyder, 15.97 grams of the material in 100 cc. of 70 per cent. alcohol. The flask was shaken at intervals of half an hour for two hours, and left overnight before filtration. Ten cubic centimeters of this solution were used for treatment by the Gunning method, after first driving off the alcohol by evaporation. By this procedure one would expect somewhat closer results than by the former.

SOFT WHEAT MEALS.			FLOUR.		
By Polariscope method.	By Gunning method.	Difference.	By Polariscope method.	By Gunning method.	Difference.
0.90	0.91	− .01	0.77	0.75	+ .02
0.70	0.69	+ .01	0.59	0.57	+ .02
0.86	0.90	− .04	0.51	0.48	+ .03
0.81	0.75	+ .06	0.46	0.43	+ .03
0.64	0.63	+ .01	0.62	0.55	+ .07
0.70	0.70	.00	0.77	0.70	+ .07
0.66	0.69	− .03	0.86	0.84	+ .02
0.92	0.94	− .02			
0.64	0.69	− .05		Average	+0.04
0.95	0.94	+ .01			
0.57	0.59	− .02			
0.55	0.60	− .05	DURUM WHEAT MEALS.		
0.73	0.71	+ .02			
0.62	0.60	+ .02			
0.62	0.66	− .04	0.84	0.83	+ .01
0.53	0.56	− .03	0.77	0.78	− .01
0.90	0.92	− .02	0.95	0.94	+ .01
0.88	0.85	+ .03	0.70	0.76	− .06
0.81	0.78	+ .03	0.66	0.69	− .03
0.70	0.70	.00	0.75	0.75	.00
0.73	0.74	− .01	0.79	0.83	− .04
0.77	0.78	+ .01	0.59	0.62	− .03
0.62	0.60	+ .02	0.81	0.78	+ .03
0.59	0.57	+ .02	0.64	0.64	.00
0.64	0.60	+ .04			
0.64	0.60	+ .04		Average	−0.02
0.55	0.58	− .03			
	Average	−0.03			

In but three cases out of the forty-five last stated does the difference between the two methods exceed 0.05, which is certainly as close as one can expect ordinary technical work to be done, and as between two samples is undoubtedly within the limits of accuracy of sampling large lots.

A still further test of the method was given by making a gliadin determination upon a gluten flour in which the Kjeldahl method showed 3.32 per cent. of gliadin nitrogen. The polariscopic method showed 3.45 per cent.

Considerable difficulty was experienced at the outset in securing a clear solution for filtration, but this was finally overcome by avoiding excessive agitation.

Snyder remarks that in the case of flours analyzed by him, and probably grown in the middle west, "the combined alcohol soluble carbohydrates and non-gliadin proteins of the alcoholic solution affect the polarization to only a slight extent," and states that after the gliadin protein was precipitated the non-gliadin rotary bodies showed a reading of less than 0.20 on the sugar scale.

In our experience with the method it was always found necessary to make two polarizations, the first on the original solution, and the second after separating the protein bodies by the use of a concentrated solution of mercuric nitrate, and then making the required correction to give the true gliadin reading.

This was particularly true in the case of wheat meals where the average difference between the two polariscope readings was 1.05 on the sugar scale corresponding to 0.21 per cent. on the gliadin scale, the range of differences on the sugar scale being from 0.08 to 2.75. In the case of flours, unless extreme accuracy is required, the correction could be neglected inasmuch as the error is much less, not exceeding 0.04 per cent. of the gliadin scale.

The writers are strongly impressed with the idea that the method is worthy of a much more extended use than it has so far had, and that if precautions are taken to correct for the effect of other optically active bodies, there are fewer opportunities for error than with the ordinary method of nitrogen determination.

NITROGEN OF COMPOUNDS SOLUBLE IN ONE PER CENT. SODIUM CHLORID SOLUTION.

Before reaching a decision as to the factor to be subtracted from the nitrogen found in the salt extract, several separations of the nitrogenous ingredients of this extract were made. Teller from his elaborate work upon this point, suggested that the factor .27 per cent. be used, and proceeded upon that basis. In discussing this question he states, however, that "two other samples showing an unusually low difference (that is, gliadin per cent. in salt extract. G. W. S.) are white wheats, each of

which contains a very low per cent. of gliadin.'' He also intimates that another factor than .27 might be preferable for such wheats. It was with the idea of ascertaining what this factor should be that the separation of the protein compounds was undertaken.

The procedure followed was as set forth under the portion of this bulletin headed ''Methods of Analysis of Cereal Products.''

First of all, to ascertain the effect of different methods of shaking to secure solution of the compounds, comparative trials were made (1) by shaking at intervals of half hours for a period of six hours, and (2) shaking in a mechanical shaker continuously for a period of six hours, the results are given in detail in the following table:

TABLE VIII.—SHOWING NITROGEN COMPOUNDS IN WHEAT MEALS SOLUBLE IN ONE PER CENT SODIUM-CHLORID SOLUTION.

Hard Wheat Meals.

Number	How Treated.	Moisture.	Total nitrogen.	Edestin nitrogen	Amid nitrogen	Gliadin nitrogen	Gliadin nitrogen calc. to dry matter.
723	Shaken at intervals for 6 hours	11.07	.43	.17	.06	.20	.224
723	Shaken continuously for 6 hours	11.07	.53	.21	.06	.26	.291
724	Shaken at intervals for 6 hours	10.70	.49	.17	.07	.25	.280
724	Shaken continuously for 6 hours	10.70	.53	.24	.06	.23	.257
727	Shaken at intervals for 6 hours	10.61	.42	.22	.06	.14	.159
727	Shaken continuously for 6 hours	10.61	.49	.20	.06	.23	.257
728	Shaken at intervals for 6 hours	10.56	.46	.23	.06	.17	.190
728	Shaken continuously for 6 hours	10.56	.51	.20	.07	.24	.269
731	Shaken at intervals for 6 hours	10.40	.48	.20	.08	.20	.223
731	Shaken continuously for 6 hours	10.40	.52	.21	.07	.24	.269
735	Shaken at intervals for 6 hours	10.70	.45	.21	.08	.16	.179
735	Shaken continuously for 6 hours	10.70	.51	.20	.06	.25	.280
	Average at 6-hour intervals	10.67	.45	.20	.07	.19	.209
	Average continuous shaking	10.67	.51	.21	.06	.24	.270

Soft Wheat Meals.

232	Shaken at intervals for 6 hours	11.42	.41	.16	.08	.17	.191
232	Shaken continuously for 6 hours	11.40	.35	.14	.07	.14	.158
237	Shaken at intervals for 6 hours	11.52	.39	.17	.08	.14	.158
237	Shaken continuously for 6 hours	11.49	.39	.14	.08	.17	.192
240	Shaken at intervals for 6 hours	11.85	.35	.15	.07	.13	.147
240	Shaken continuously for 6 hours	11.90	.42	.18	.08	.16	.181
242	Shaken at intervals for 6 hours	11.36	.46	.17	.08	.21	.236
242	Shaken continuously for 6 hours	11.32	.48	.18	.07	.23	.259
245	Shaken at intervals for 6 hours	10.73	.43	.17	.07	.19	.212
245	Shaken continuously for 6 hours	11.75	.42	.15	.07	.20	.226
246	Shaken at intervals for 6 hours	10.70	.35	.15	.05	.15	.160
246	Shaken continuously for 6 hours	10.75	.41	.18	.07	.16	.179
	Average at intervals for 6 hours	10.27	.40	.16	.07	.16	.187
	Average continuous shaking	11.43	.41	.16	.07	.18	.199

Soft Wheat Flours.

Number	How Treated.	Moisture.	Total nitrogen.	Edestin nitrogen	Amid nitrogen	Gliadin nitrogen	Gliadin nitrogen calc. to dry matter.
19, 24	Shaken at intervals for 6 hours	10.99	.36	.12	.03	.21	.235
19, 24	Shaken continuously for 6 hours	10.99	.36	.10	.04	.22	.250
248	Shaken at intervals for 6 hours	11.35	.36	.12	.03	.21	.237
248	Shaken continuously for 6 hours	11.35	.36	.11	.03	.22	.249
266	Shaken at intervals for 6 hours	11.25	.31	.09	.03	.19	.214
266	Shaken continuously for 6 hours	11.25	.31	.08	.03	.20	.226
268	Shaken at intervals for 6 hours	11.13	.29	.09	.02	.18	.202
268	Shaken continuously for 6 hours	11.13	.31	.08	.03	.20	.225
288	Shaken at intervals for 6 hours	10.40	.36	.12	.03	.21	.245
288	Shaken continuously for 6 hours	10.40	.38	.10	.03	.25	.279
512	Shaken at intervals for 6 hours	10.70	.41	.12	.02	.27	.302
512	Shaken continuously for 6 hours	10.70	.41	.13	.04	.24	.272
	Average at 6-hour intervals	10.97	.35	.11	.03	.21	.237
	Average for 6 hours shaking	10.97	.35	.10	.03	.22	.250
	General average, intervals	10.64	.40	.16	.06	.19	.211
	General average, continuous	10.64	.42	.16	.05	.21	.239

An examination of this table shows that the continuous shaking would have given slightly higher results, but they would not have been materially changed by such procedure, and so far as the general run of technical work is concerned the interval shaking is doubtless entirely satisfactory.

Adopting as the basis of the work the classification of the proteids of wheat as previously set forth, a nextract was obtained from 4 grams of finely ground wheat meals by means of a 1 per cent. sodium chlorid solution and aliquot portions used for the direct determinations of total nitrogen, edestin and leucosin nitrogen, and of amid nitrogen. The difference between the sum of these, and the total, was presumed to represent gliadin nitrogen that had been dissolved by the salt solution. Throughout this work the shaking was done at intervals of a half hour for a period of six hours.

TABLE IX.—SHOWING NITROGEN OF COMPOUNDS SOLUBLE IN ONE PER CENT SODIUM CHLORID SOLUTION.

Number.	Name.	Moisture.	Total nitrogen.	Edestin and leucosin nitrogen.	Amid nitrogen.	Gliadin nitrogen.	Gliadin nitrogen calc. to dry matter.
205	Wheat meal	12.00	.35	.16	.08	.11	.125
205	Wheat meal	11.89	.37	.16	.08	.13	.147
	Average	11.945	.36	.16	.08	.12	.136
206	Wheat meal	12.28	.38	.17	.10	.11	.125
206	Wheat meal	12.21	.37	.17	.10	.10	.114
	Average	12.245	.375	.17	.10	.105	.1195
212	Wheat meal	11.63	.46	.17	.15	.14	.158
212	Wheat meal	11.55	.45	.17	.16	.12	.135
	Average	11.59	.455	.17	.155	.13	.1465
231	Wheat meal	11.85	.36	.17	.06	.13	.147
231	Wheat meal	11.68	.39	.17	.07	.14	.158
	Average	11.765	.375	.17	.065	.135	.1525
232	Wheat meal	11.42	.41	.16	.08	.17	.191
232	Wheat meal	11.37	.38	.14	.10	.13	.146
	Average	11.395	.395	.15	.09	.15	.1685
233	Wheat meal	11.66	.46	.20	.09	.17	.190
233	Wheat meal	11.84	.48	.20	.09	.18	.207
	Average	11.75	.47	.20	.09	.175	.1985
237	Wheat meal	11.52	.39	.17	.08	.14	.158
237	Wheat meal	11.46	.41	.19	.09	.13	.146
	Average	11.49	.40	.18	.085	.135	.152
242	Wheat meal	11.36	.46	.17	.08	.21	.236
242	Wheat meal	11.28	.46	.17	.08	.19	.214
	Average	11.32	.46	.17	.08	.20	.225
245	Wheat meal	10.73	.43	.17	.07	.19	.212
245	Wheat meal	10.77	.42	.17	.07	.18	.201
	Average	10.75	.425	.17	.07	.185	.2065
240	Wheat meal	11.85	.35	.15	.07	.13	.147
240	Wheat meal	11.95	.34	.15	.07	.12	.136
	Average	11.90	.345	.15	.07	.125	.1415
246	Wheat meal	10.70	.35	.15	.05	.15	.160
246	Wheat meal	10.81	.35	.14	.06	.15	.160
	Average	10.755	.35	.145	.065	.15	.160
247	Wheat meal	11.30	.41	.15	.06	.20	.225
247	Wheat meal	11.54	.39	.14	.06	.19	.214
	Average	11.42	.40	.145	.06	.195	.2195
248	Wheat meal	11.02	.35	.15	.04	.16	.179
248	Wheat meal	10.97	.36	.12	.05	.19	.213
	Average	10.995	.355	.135	.045	.175	.196
249	Wheat meal	11.10	.34	.14	.05	.15	.167
249	Wheat meal	10.95	.35	.13	.06	.16	.179
	Average	11.025	.345	.135	.055	.155	.173
254	Wheat meal	11.02	.35	.12	.05	.18	.202
254	Wheat meal	10.66	.34	.12	.05	.17	.192
	Average	10.84	.345	.12	.05	.175	.197
	Grand average soft wheat meals	11.41	.39	.16	.076	.154	.173

TABLE IX (*continued.*)

Number.	Name.	Moisture.	Total nitrogen.	Edestin and Leucosin nitrogen.	Amid nitrogen.	Gliadin nitrogen.	Gliadin nitrogen calc. to dry matter.
721	Hard wheat meal	10.71	.45	.19	.06	.20	.223
721	Hard wheat meal	10.71	.43	.17	.06	.20	.223
	Average	10.71	.44	.18	.06	.20	.223
722	Hard wheat meal	10.78	.43	.19	.06	.18	.201
723	Hard wheat meal	11.07	.43	.17	.06	.20	.224
724	Hard wheat meal	10.70	.49	.17	.07	.25	.28
727	Hard wheat meal	10.61	.42	.22	.06	.14	.159
728	Hard wheat meal	10.56	.46	.23	.06	.17	.190
729	Hard wheat meal	10.46	.48	.22	.07	.19	.212
731	Hard wheat meal	10.40	.48	.20	.08	.20	.223
735	Hard wheat meal	10.70	.45	.21	.08	.16	.179
	Grand average hard wheat meals	10.66	.45	.201	.066	.189	.20
19, 24	Flour	10.99	.36	.12	.03	.21	.235
248	Flour	11.35	.36	.12	.03	.21	.237
266	Flour	11.25	.31	.09	.03	.19	.214
268	Flour	11.13	.29	.09	.02	.18	.202
288	Flour	10.40	.36	.12	.03	.21	.245
512	Flour	10.70	.41	.12	.02	.27	.302
513	Flour	10.90	.39	.13	.02	.24	.266
	Grand average flour	10.97	.354	.11	.025	.215	.243

From these results it was decided to use the factor .15 per cent. as representing more nearly the gluten constituents, which pass into the salt solution in the treatment of soft wheat meals, than the one suggested by Teller, in the case of the so-called hard wheats. The other work indicates, however, that a somewhat higher factor should be used for the hard winter and durum wheats, and a still higher factor for flours. The markedly higher factor for flours undoubtedly is brought about from their finer condition. Even here, however, the factor appears to be lower than that suggested by Teller (.27), for in but one case out of the entire number did the figures rise as high as that.

DISCUSSION OF ANALYSIS OF WHOLE WHEAT.

Previous to analysis the samples were all held in the storeroom under uniform conditions for several weeks to secure greater uniformity in moisture condition. Each sample was freed from all foreign matter, such as weed seed, chaff, pieces of straw, dirt, etc., previous to being ground to a fine meal for analysis. The analysis of plump kernels only is recorded in these tables and in this respect the samples are strictly comparable. For the better comparison of results all the chemical data has been calculated to the basis of dry matter, but the percentage of moisture in the original is recorded in each case.

It is of particular interest in the first place to compare the several varieties one with another. At the bottom of each table of varieties is given the average for each of the respective varieties. The averages are also set forth in a separate table (Table XIV).

TABLE X.—SHOWING CHEMICAL CHARACTERISTICS OF WASHINGTON BLUESTEM WHEAT.

Number of sample.	Physical.		Chemical.										
				Calculated to dry matter.									
					Gluten.								
					Gliadin.		Glutenin.						
	Number kernels in 10 grams.	Relative hardness.	Moisture.	Total protein.	Per cent of wheat.	Per cent of total protein.	Per cent of wheat.	Per cent of total protein.	Total per cent of wheat.	Gliadin-glutenin ratio.	Non-gluten protein.	Ash.
64	225	437	12.80	10.14	4.20	41.48	4.05	40.00	8.25	51–49	1.89	2.05
606	231	445	12.57	10.30	3.28	31.96	5.45	52.94	8.73	38–62	1.57	----
118	237	408	12.69	10.68	4.20	39.33	4.92	46.09	9.12	44–56	1.56	2.13
17	242	237	11.76	11.91	5.33	44.81	3.08	25.88	8.41	63–37	3.50	2.13
24	242	222	11.48	11.51	6.30	54.76	3.47	30.22	9.77	64–36	1.74	2.12
25	243	193	12.64	13.87	4.65	33.58	7.07	50.99	11.72	40–60	2.15	2.03
152	245	287	13.36	10.26	4.15	40.58	4.53	44.21	8.68	48–52	1.58	2.14
9	257	231	10.23	9.05	3.55	39.23	2.90	32.10	6.45	55–45	2.60	2.02
303	263	367	9.68	9.31	3.17	34.13	4.86	52.2	8.03	39–61	1.28	----
121	267	342	11.81	9.01	3.57	39.13	4.01	43.97	7.58	47–53	1.43	1.95
268	268	260	12.44	7.29	2.54	34.95	3.39	46.55	5.93	43–57	1.36	1.99
196	270	----	9.18	10.18	3.63	35.67	5.05	49.62	8.68	42–58	1.50	1.97
472	271	353	13.72	12.26	3.88	31.4	6.84	55.34	10.72	36–64	1.54	1.80
15a	277	291	12.84	9.27	3.04	32.85	4.79	51.66	7.83	39–61	1.44	2.14
10a	277	247	11.89	8.76	2.89	33.03	4.36	49.87	7.25	40–60	1.51	1.98
10	277	----	11.77	12.14	4.47	37.92	4.72	39.05	9.19	49–51	2.95	2.09
16	279	171	11.27	10.94	5.78	51.69	1.96	17.92	7.74	74–26	3.20	2.18
15	280	171	11.01	10.91	5.02	46.03	2.42	22.24	7.44	67–33	3.47	2.26
4	285	167	11.27	8.98	4.31	48.05	3.44	38.39	7.75	56–44	1.23	2.20
14	287	218	11.22	12.79	5.83	45.59	3.49	27.29	9.32	63–37	3.45	2.25
13	289	----	10.80	11.15	4.29	38.49	3.67	32.96	7.96	54–46	3.19	2.06
391	297	----	14.17	11.60	3.34	36.01	4.35	46.92	7.69	43–57	3.91	1.95
299	298	285	9.44	8.08	3.12	38.66	3.45	42.76	6.57	48–52	1.51	1.94
385	299	----	12.16	10.25	3.41	33.30	5.29	51.61	8.70	39–61	1.55	----
325	303	----	12.34	8.52	2.56	30.12	4.40	51.67	6.96	37–63	1.56	----
267	309	224	11.73	7.36	2.57	34.92	3.56	48.46	6.13	42–58	1.23	2.00

206	313	226	12.83	8.85	3.01	34.07	4.32	48.83	7.33	41–59	1.52	2.20
205	313	212	12.83	7.18	2.60	36.26	3.01	42.01	5.61	46–54	1.57	1.98
300	314	276	10.06	8.95	3.41	38.41	3.63	40.74	7.04	48–52	1.91	
5	314	165	10.48	13.71	5.17	37.70	6.38	46.58	11.55	45–55	2.16	1.89
101	319		12.53	14.40	4.23	28.80	7.39	51.35	11.62	36–64	2.78	2.26
386	334	231	12.18	9.53	3.08	32.3	4.94	51.85	8.02	39–61	1.51	1.61
272	350	321	13.06	7.15	1.98	27.81	3.79	53.05	5.77	34–66	1.38	2.01
Average	281	289	11.80	10.18	3.83	37.4	4.33	48.6	8.16	46–54	2.06	2.02

TABLE XI.—SHOWING CHEMICAL CHARACTERISTICS OF WHITE AUSTRALIAN WHEAT.

California number of sample.	Physical.		Chemical.										
				Calculated to dry matter.									
					Gluten.								
					Gliadin.		Glutenin.						
	Number kernels in 10 grams.	Relative hardness.	Moisture.	Total protein.	Per cent of wheat.	Per cent of total protein.	Per cent of wheat.	Per cent of total protein.	Total per cent of wheat.	Gliadin-glutenin ratio.	Non-gluten protein.	Ash.	
452	216	395	13.10	9.43	4.02	42.61	3.897	41.31	7.91	50–49	1.516	--------	
462	228	--------	13.08	10.27	3.394	33.03	5.315	51.73	8.71	38–61	1.565	--------	
461	231	--------	13.10	10.01	3.095	30.92	5.351	53.45	8.45	36–63	1.565	--------	
460	236	--------	13.03	9.44	2.83	29.96	5.05	53.47	7.88	36–64	1.56	--------	
26	237	434	12.07	13.42	4.63	34.49	7.02	52.29	11.65	40–60	1.77	2.16	
67	240	401	12.11	11.41	4.45	38.98	5.42	47.48	9.87	45–55	1.54	2.28	
73	249	375	11.51	9.83	4.10	41.72	3.81	38.74	7.91	52–48	1.92	1.90	
382	255	--------	12.21	7.35	2.13	29.10	3.68	50.16	5.81	36–64	1.54	--------	
127	256	232	11.50	8.27	3.11	37.56	3.63	43.85	6.74	46–54	1.53	1.98	
605	256	443	12.41	10.83	3.72	34.35	5.56	51.32	9.28	40–60	1.55	--------	
129	259	240	11.45	9.18	3.47	37.76	4.18	45.51	7.65	45–55	1.53	2.08	
68	260	362	12.59	11.02	4.84	43.87	4.63	42.01	9.47	51–49	1.55	2.13	
66	261	396	12.63	9.86	4.20	42.57	4.10	41.65	8.30	51–49	1.56	2.12	
23	264	111	11.49	12.06	6.49	53.74	2.73	22.66	9.22	70–30	2.84	2.06	
62	267	248	11.57	11.43	4.83	42.23	4.49	39.27	9.32	52–48	2.11	2.17	
453	268	410	12.39	10.10	3.29	32.54	5.26	52.09	8.55	38–62	1.55	2.20	
311	268	323	11.20	8.36	2.87	34.32	3.90	46.57	6.77	42–58	1.59	2.05	
398	269	--------	12.18	8.16	2.56	31.38	4.05	49.65	6.61	39–61	1.54	--------	
231	272	381	12.18	7.72	2.45	31.71	3.92	50.74	6.37	38–62	1.35	1.92	
381	272	--------	12.27	9.54	3.13	32.85	4.86	50.90	7.99	39–61	1.55	--------	
304	274	327	8.88	10.15	3.24	31.89	4.98	49.08	8.22	39–61	1.93	1.99	
320	277	--------	12.09	9.89	2.99	30.23	5.36	54.14	8.35	36–64	1.54	--------	
383	279	346	12.68	9.77	3.47	35.43	4.62	47.19	8.09	43–57	1.68	1.82	
134	280	172	12.15	9.90	3.95	39.88	4.41	45.51	8.36	47–53	1.54	--------	
288	281	365	14.75	9.63	3.27	34.00	3.94	47.99	6.73	41–59	2.12	2.13	
232	288	289	12.51	6.92	2.37	34.16	3.19	46.04	5.56	43–57	1.36	1.93	

69	293	278	12.73	13.36	6.35	47.51	4.09	30.62	10.44	61–39	2.92	2.04
138	298	165	12.01	10.86	4.49	41.31	4.83	44.46	9.32	48–52	1.54	2.01
184	298	199	9.41	11.07	3.26	29.41	5.87	53.04	9.13	36–64	1.84	2.00
271	298	----------	11.81	7.73	1.98	25.66	4.21	54.40	6.19	32–68	1.54	----------
322	299	324	14.36	8.54	3.35	39.21	3.61	42.21	6.96	48–52	1.58	2.09
28	300	355	12.35	9.27	4.37	47.18	1.85	19.93	6.22	70–30	3.05	1.96
275	302	241	12.56	7.79	2.87	36.81	3.56	45.60	6.43	45–55	1.36	1.86
22	306	355	12.52	13.21	6.74	51.03	3.32	25.09	10.06	63–37	3.15	1.93
141	316	171	9.90	13.00	5.02	38.23	6.60	50.17	11.62	43–59	1.48	1.90
326	326	293	12.50	10.48	2.91	27.81	6.01	57.36	8.92	33–67	1.56	1.53
23a	328	328	11.71	9.95	3.34	33.91	5.11	51.84	8.45	40–60	1.50	1.89
309	330	349	9.83	9.38	4.92	51.9	2.64	27.78	7.56	65–35	1.82	1.95
312	330	325	13.21	7.97	3.77	47.26	2.50	31.27	6.27	60–40	1.70	1.89
259	331	----------	11.23	7.36	1.86	25.23	3.98	53.98	5.84	32–68	1.52	----------
78	337	240	11.54	11.07	4.47	40.30	4.88	44.08	9.35	48–52	1.72	2.01
77	342	264	11.41	10.53	4.28	40.62	4.14	39.34	8.42	51–49	2.11	2.21
251	357	----------	12.54	9.67	2.56	26.48	5.56	57.21	8.12	32–68	1.55	----------
319	369	227	9.92	8.55	3.22	37.42	3.60	41.85	6.82	47–53	1.73	2.03
310	375	184	11.31	8.25	2.33	28.28	4.13	50.00	6.46	37–63	1.79	2.20
Average	286	305	11.75	9.81	3.44	35.1	4.39	45.1	7.83	46–54	1.98	2.01

TABLE XII.—SHOWING CHEMICAL CHARACTERISTICS OF LITTLE CLUB WHEAT.

California number of sample.	Physical.		Chemical.										
				Calculated to dry matter.									
					Gluten.								
					Gliadin.		Glutenin.						
	Number kernels in 10 grams.	Relative hardness.	Moisture.	Total protein.	Per cent of wheat.	Per cent of total protein.	Per cent of wheat.	Per cent of total protein.	Total per cent of wheat.	Gliadin-glutenin ratio.	Non-gluten protein.	Ash.
459	226	----------	11.28	13.64	4.94	36.14	7.19	52.64	12.13	41–59	1.51	1.83
443	236	----------	12.74	10.05	3.24	32.27	5.25	52.22	8.49	38–62	1.56	1.98
436	243	----------	12.96	8.58	2.81	32.80	4.21	49.00	7.02	40–60	1.56	2.17
446	243	----------	12.15	8.60	2.96	34.23	4.09	47.62	7.05	42–58	1.55	2.02
440	244	----------	12.31	9.27	2.95	31.86	4.77	51.42	7.72	38–62	1.55	2.03
439	247	----------	12.46	8.91	2.82	31.67	4.54	50.90	7.36	38–62	1.55	1.98
607	248	----------	12.32	8.07	2.71	33.62	3.81	47.18	6.52	42–58	1.55	--------
449	252	----------	11.98	8.95	2.81	31.35	4.60	51.40	7.41	38–62	1.54	2.07
445	255	----------	11.12	9.23	2.81	30.57	4.89	52.85	7.71	37–63	1.52	2.01
448	263	----------	12.45	9.55	2.95	30.82	5.06	52.93	8.01	37–63	1.54	2.07
124	271	244	11.43	9.08	3.60	39.62	3.95	43.48	7.55	48–52	1.53	1.96
438	274	----------	12.32	9.27	2.81	30.25	4.92	53.01	7.73	36–64	1.54	2.02
130	282	235	11.35	9.08	3.60	39.62	3.95	43.48	7.55	48–52	1.53	2.00
437	284	----------	12.41	8.36	2.56	30.60	4.25	50.82	6.81	38–62	1.55	2.04
444	285	----------	12.24	12.53	4.80	38.27	6.18	49.33	10.98	44–56	1.55	2.25
28a	286	242	11.69	9.02	3.34	37.20	4.10	45.42	7.44	45–55	1.58	1.94
442	289	----------	11.12	9.23	3.09	33.50	4.61	49.94	7.70	40–60	1.53	1.90
6	292	272	10.80	13.43	3.85	28.58	7.57	56.25	11.42	34–66	2.01	2.04
1	295	----------	11.56	10.10	4.30	42.55	3.62	35.83	7.92	54–46	2.18	2.22
144	306	186	11.91	8.58	2.43	28.97	3.91	45.50	6.34	38–62	2.24	2.12
139	314	211	13.08	9.26	2.72	29.32	4.65	50.19	7.37	35–65	1.89	1.98
128	315	227	11.40	8.18	3.15	32.96	3.50	42.76	6.65	47–53	1.53	2.10
51	316	77	12.07	8.40	2.76	32.88	4.29	50.21	7.05	39–61	1.35	1.90
51a	317	77	11.77	9.21	2.89	31.36	5.01	51.91	7.90	39–61	1.30	2.18
266	317	----------	12.48	7.38	2.55	34.52	3.51	47.52	6.06	42–58	1.32	1.98

12	327	---	11.99	7.87	3.22	40.83	2.84	36.08	6.06	54–46	1.81	1.82
315	330	181	10.52	8.18	2.94	35.93	3.86	47.13	6.80	43–57	1.38	1.94
161	330	275	12.46	8.08	3.00	37.14	3.53	43.56	6.53	46–54	1.55	2.08
8	332	202	10.86	7.83	4.38	55.87	1.93	24.64	6.31	69–31	1.52	2.24
27	334	340	12.22	13.53	3.73	27.52	8.21	60.69	11.94	31–69	1.59	2.11
2	336	---	11.48	11.60	5.14	44.30	2.80	24.15	7.94	65–35	3.66	1.95
53	336	281	12.81	8.76	3.43	39.13	3.84	43.85	7.27	47–53	1.49	2.28
143	337	198	11.80	9.03	2.86	131.62	4.18	46.30	7.04	41–58	1.99	1.97
145	340	---	11.75	11.45	4.00	35.73	4.57	40.79	8.57	47–53	2.98	2.05
11	340	174	11.64	11.35	5.50	48.45	3.09	27.22	8.59	64–36	2.76	1.92
59	342	289	12.35	8.34	3.32	39.72	3.55	42.49	6.87	48–52	1.47	2.20
80	355	293	11.69	10.38	4.43	42.63	4.42	42.53	8.85	50–50	1.53	1.90
57	356	268	12.20	8.41	3.22	38.29	3.71	44.11	6.93	46–54	1.48	2.05
321	360	---	12.01	8.59	2.70	31.48	4.34	50.53	7.04	38–62	1.55	---
21	360	181	11.92	13.39	6.24	46.44	3.93	29.32	10.17	61–39	3.22	2.27
50	363	---	12.16	8.61	4.13	48.01	2.52	29.23	6.65	62–38	1.96	2.11
56	363	256	12.64	10.13	4.11	40.56	4.33	42.71	8.44	49–51	1.69	1.99
49	363	122	12.44	9.19	3.55	38.63	1.53	16.65	5.08	70–30	4.11	2.17
50a	363	23	12.17	8.97	2.90	32.36	4.57	50.89	7.47	39–61	1.50	2.04
58	366	286	12.24	8.17	3.18	38.91	3.44	42.12	6.62	48–52	1.55	2.10
277	367	189	13.01	9.05	3.30	36.42	4.33	47.84	7.63	43–57	1.42	1.78
53	373	226	12.90	7.50	2.65	35.32	3.43	45.72	6.08	43–57	1.42	2.20
60	377	152	12.00	8.77	3.81	43.39	3.28	37.44	7.09	54–46	1.68	2.22
305	377	205	11.78	8.61	2.44	28.29	4.95	57.50	7.39	33–67	1.22	1.75
314	389	---	12.02	10.06	3.41	33.90	5.10	50.74	8.51	40–60	1.55	---
54	390	282	12.26	9.54	4.05	42.41	4.01	42.05	8.06	50–50	1.48	2.14
55	390	232	11.79	8.46	3.34	39.49	3.33	39.36	6.67	50–50	1.79	2.09
317	419	150	11.09	8.15	2.96	36.28	3.53	43.31	6.49	46–54	1.66	1.91
297	462	---	11.65	8.74	3.26	37.31	3.94	45.08	7.20	45–55	1.54	---
290	537	250	10.21	10.39	3.82	36.70	5.06	48.66	8.88	43–57	1.51	2.17
Average	324	214	12.01	9.35	3.43	36.68	4.23	45.24	7.66	45–55	1.69	2.04

TABLE XIII.—SHOWING CHEMICAL CHARACTERISTICS OF SONORA AND PROPO WHEATS.

Sonora.

California number of sample.	Physical.		Chemical.										
				Calculated to dry matter.									
					Gluten.								
					Gliadin.		Glutenin.						
	Number kernels in 10 grams.	Relative hardness.	Moisture.	Total protein.	Per cent of wheat.	Per cent of total protein.	Per cent of wheat.	Per cent of total protein.	Total per cent of wheat.	Gliadin-glutenin ratio.	Non-gluten protein.	Ash.
167	254	303	12.66	14.60	4.70	32.21	8.34	57.13	13.04	36–64	1.56	2.16
482	267	----------	12.67	9.49	3.14	33.17	4.78	50.42	7.92	40–60	1.51	----------
265	270	----------	12.88	7.59	2.27	29.91	3.76	49.55	6.03	38–62	1.56	----------
481	272	479	12.45	10.01	3.36	33.6	4.82	48.11	8.18	37–63	1.83	1.82
245	283	414	11.76	8.83	2.85	32.31	4.44	50.26	7.29	39–61	1.54	----------
228	296	----------	12.53	7.84	2.26	28.86	4.02	51.31	6.28	36–64	1.56	----------
74	296	370	11.84	9.77	4.07	41.64	3.77	38.63	7.84	52–48	1.93	2.01
269	332	----------	12.54	8.00	2.28	28.57	4.16	52.00	6.44	36–64	1.56	----------
76	337	408	11.38	9.08	3.46	38.13	4.08	44.97	7.54	46–54	1.54	2.11
33	356	422	12.88	8.76	3.66	41.75	3.08	35.21	6.74	54–46	2.02	1.95
63	359	303	12.16	15.80	7.53	47.62	5.87	37.18	13.40	56–44	2.40	1.82
252	371	----------	11.98	9.05	2.70	29.86	4.80	53.07	7.50	36–64	1.55	----------
246	371	----------	11.85	8.99	2.83	31.53	4.61	51.32	7.44	38–62	1.55	----------
249	371	372	12.05	9.33	3.21	34.47	4.70	50.43	7.91	40–60	1.42	1.89
140	444	203	12.20	12.11	4.55	37.45	4.35	40.73	8.90	48–52	3.21	2.20
137	457	186	10.31	7.80	3.64	46.71	2.64	33.85	6.28	58–42	1.52	1.97
257	518	221	12.34	8.03	2.58	32.24	2.93	36.51	5.51	56–44	2.52	1.98
Average	344	336	12.14	9.71	3.48	35.84	4.42	45.52	7.90	44–56	1.61	1.99

Propo.

46	236	374	11.96	10.50	4.53	42.76	3.74	35.37	8.27	55–45	2.23	2.05
387	263	----------	10.30	8.97	3.31	36.89	4.15	46.21	7.46	44–56	1.51	1.85
45	270	289	12.00	9.96	3.89	39.09	4.45	44.70	8.34	47–53	1.62	2.05
414	291	----------	9.88	9.07	3.55	35.28	4.51	49.61	8.06	42–58	1.01	1.91
47	322	311	11.90	11.94	5.39	45.15	3.84	36.5	9.23	55–45	2.71	1.94
79	341	260	11.90	11.76	4.84	42.23	5.08	44.31	9.92	49–51	1.84	2.17
Average	287	308	11.32	10.37	4.25	40.23	4.30	42.78	8.55	50–50	1.82	2.00

TABLE XIV.—GENERAL AVERAGE.

Variety.	Physical.		Chemical.									
				Calculated to dry matter.								
					Gluten.							
					Gliadin.		Glutenin.					
	Number of samples represented.	Number kernels in 10 grams.	Moisture.	Total protein.	Per cent of wheat.	Per cent of total protein. Gliadin number.	Per cent of wheat.	Per cent of total protein.	Total per cent of wheat.	Gliadin-glutenin ratio.	protein. Non-gluten	Ash.
White Australian	42	280	12.05	9.89	3.74	37.81	4.39	44.39	8.13	46–54	1.76	2.01
Bluestem	33	281	11.80	10.18	3.83	37.40	4.33	48.60	8.16	46–54	2.06	2.02
Little Club	52	324	12.01	9.35	3.43	36.68	4.23	45.24	7.66	45–55	1.69	2.04
Sonora	17	344	12.14	9.71	3.48	35.84	4.42	45.52	7.90	44–56	1.61	1.99
Propo	5	280	11.53	10.64	4.44	40.90	4.32	42.09	8.76	49–51	1.88	2.02
Grand average	149	298	12.11	9.95	3.78	37.7	4.34	45.2	8.29	46–54	1.66	2.01

The first thing which is apparent from this table of averages is the much larger moisture content for these wheats than is usually stated for wheats. In fact the variety tables show quite a range in moisture, all the way from a maximum of 14.17 in No. 391 to 9.18 per cent. in No. 196, with a general average for all samples of 12.11 per cent. This is a considerably higher figure than it was expected to find, especially as the analyses for the most part were made during the dry season. Richardson, as an average of 310 samples of American grown wheats, gives 10.50, and in these samples there is also a wide difference between individual samples, viz., from 7.1 per cent. to 14 per cent.

In the case of results here stated wherever there seemed to be any question, the work was checked by a duplicate determination. This generally high moisture content of the samples may perhaps be partially explained from the fact that the laboratory is situated comparatively near the bay and the atmosphere is usually quite moisture-laden even during the summer. That grain absorbs moisture from the air very readily, has been shown by experiments carried on at this Station in bringing grain from the interior sections of the State where the atmosphere is very dry to the coast region. Undoubtedly this fact has had much to do with producing the condition here shown.

It is claimed that the moisture that wheat will thus absorb during a voyage from San Francisco to Liverpool will sometimes increase its weight enough to pay the entire cost of freight (?). In the experiments above indicated it was shown by Dr. Hilgard that wheat from the inland portions of the State might increase as much as 25 per cent. by absorption of moisture, while a gain of 5 to 15 per cent. may be looked for with absolute certainty. A difference of 9 per cent. was observed in twenty-four hours. *It is barely possible that this* increased moisture content may have some chemical influence upon the quality of the gluten which is a matter that will be again touched upon.

As to protein content the varieties stand in the following order, Propo, Bluestem, Australian, Sonora, and Little Club. This is the more noteworthy since it is in the same order that the miller would probably class these wheats. Thus it seems that a determination of the total protein, or what amounts to the same thing, the total nitrogen, would serve to classify the varieties in a very general manner as to adaptability for milling, aside from their physical characteristics.

In 310 analyses of American wheats compiled to 1890, the protein content (N x 6.25) varied from 8.1 to 17.2, with an average of 11.9 per cent. in samples carrying 10.5 per cent. average moisture content, which calculated to the same basis of dry matter and factor as presented in

these wheats would correspond to an average of 12.08 per cent. The analyses here shown give an average protein content of the white wheats of 9.95 per cent. in the dry matter, or about 2 per cent. lower than the general average of the common wheats of the country.

The gliadin follows the same order as the total protein. The glutenin, however, does not follow the reverse order, without a variation in the order of arrangement in the wheats, owing to a variation of the non-gluten proteids. It will be seen that in the matter of non-gluten proteids Bluestem exceeds the others quite materially. The effect of this is to reduce the glutenin, and thus to displace this variety from the order shown by the total protein. The gluten, chemically determined, runs in the same direction as the total protein, which would necessarily follow unless the non-gluten proteids were unduly large and the difference in gluten between any two varieties very small.

Another thing which appears from the table is that as between varieties neither the total protein nor the gliadin bear any definite relation to the size of the kernels.

Turning attention to the proportion of total protein of wheats existing in the form of gluten, as determined chemically, we find as follows:

Bluestem	80.2 per cent.
White Australian	82.9 per cent.
Little Club	81.9 per cent.
Sonora	81.4 per cent.
Propo	82.3 per cent.
Average	8.15 per cent.

There is shown to be very little difference in the ash content of the varieties. It is seen that the ash does not follow the size of the kernel closely, as it does in the north central states, nor is there as large a percentage. In a general way it follows within the type, but the particular character of the wheat not within the same type breaks the order in this regard. Thus a Sonora sample, with its thin bran, which part contains the larger portion of ash, carries a considerably lower per cent than does a Bluestem sample with the same size grains. As compared with the average ash content of the United States wheats, the California grown varieties are relatively low.

It is the custom to consider both the gliadin-glutenin ratio and the gliadin number in connection with flours rather than the whole wheats, because the operation of milling changes the relation of the ingredients to a greater or less extent, but since it is highly desirable for us to make certain comparisons of grain before more than a very few plants can be had, and since, further, it was desired to ascertain what was the result

of milling upon this ratio in the case of the common white wheats, these data are also calculated for the whole berry, as well as for the flour later. To either the miller or baker it will have its greatest significance in connection with the flour.

Since the larger part of the gliadin is in the endosperm of the grain the milling will of course raise the gliadin number of the flour above that of the whole wheat.

While Table XIV shows an appreciable difference between one variety and another, within the same variety there is even a greater difference between individual samples than between the several varieties, as will be seen by referring to the minimum, maximum, and average results, as subjoined:

	Maximum protein.	Minimum protein.	Average protein.
Bluestem	14.40	7.15	10.18
White Australian	13.42	6.92	9.89
Little Club	13.53	7.38	9.35
Sonora	15.80	7.59	9.71
Propo	11.94	8.97	10.64

Australian, for instance, shows a range of from 6.92 per cent. of total protein in the dry matter of No. 232 to 13.42 per cent. in No. 26.

Very generally speaking the gliadin seems to rise and fall with the total protein, but there seems to be no definite or absolute ratio between the two. This is also in accord with most other results that have been published. There are exceptions even to this statement that the gliadin rises and falls with the total protein in whole wheat; as witness, samples 326 and 312, the former carrying 10.48 per cent. total protein and 2.91 per cent. gliadin, and the latter showing but 7.97 per cent. total protein but rising in gliadin content to 3.77 per cent. Still, while individual instances of this kind do occur, it may be said that in general the gliadin does follow the trend of the total protein but does not bear any definite ratio to it.

The same statements hold concerning the other varieties, although Bluestem appears to run more even than White Australian. Little Club, while generally running lower in protein, has certain lots which rank very high in this group of compounds, as for instance Nos. 459, 444, 6, 27, and 29, *which suggests that it might be possible to fix these characteristics to a certain extent at least,* even in this variety. The

unreliability of this variety in its present condition, however, has given it a very low standing among millers.

These cases of unusually high protein content are also apparent in the other varieties. The underlying causes of such wide variation are not apparent as yet. One would at first, perhaps, assume that it was due to soil conditions of the locality, but an examination of the record accompanying each sample does not reveal anything definite in this direction.

In this connection it is interesting to record a series of analyses of grain taken from the entire product of individual plants. Each of the samples used for the analyses stated below were made up by using the grain from one half of each head of an individual plant. Even here, in the case of the three varieties cited, there will be noted the great variation between individual plants, and these were grown under exactly the same climate and as near as possible upon the same character of soil. The variation in individual plants of Australian ranges from a minimum of 9.06 to 15.31 per cent. total protein, or a variation of 6.25 per cent. within 25 plants, and the range in Little Club is even greater, being from 7.12 to 16.22. Such a variation as here appears among individual plants, grown under the same conditions of soil and climate, would seem to cast grave doubt as to the effect of climate or soil upon the composition of the grain, except in a very general manner, and to throw the ultimate causes of difference within the plant itself.

TABLE XV.—SHOWING CERTAIN VARIATIONS BETWEEN INDIVIDUAL PLANTS OF WHEAT.

Club—California No. 459.					Australian—California 452.					Propo.				
Centgener number.	Number kernels in plant.	Weight of kernels per plant (grams).	Per cent nitrogen in kernels.	Per cent total protein.	Centgener number.	Number kernels in plant.	Weight of kernels per plant (grams).	Per cent nitrogen in kernels.	Per cent total protein.	Centgener number.	Number kernels in plant.	Weight of kernels per plant (grams).	Per cent nitrogen in kernels.	Per cent total protein.
4718	219	10.241	1.714	9.74	4813	103	3.7808	2.182	12.39	7317	144	7.0617	1.793	10.18
4704	244	10.538	2.614	14.85	4818	119	5.0306	1.835	10.42	7315	150	7.2607	1.864	10.59
4711	244	10.451	2.646	15.03	4821	121	5.0302	2.345	13.32	7316	150	5.9803	2.078	11.80
4722	246	11.143	1.279	7.26	4810	123	4.9826	1.740	9.88	7302	168	8.8266	1.944	11.04
4723	254	11.254	2.031	11.54	4809	128	5.1400	1.954	11.10	7310	173	8.1147	1.786	10.14
4701	263	12.480	2.232	12.68	4816	128	5.8740	1.732	9.84	7318	173	9.2274	1.852	10.52
4721	264	9.397	2.758	15.67	4814	135	5.5290	1.752	9.95	7320	199	9.5840	1.776	10.09
4707	266	11.797	2.359	13.40	4819	139	5.9616	1.609	9.14	7311	200	7.7578	1.855	10.54
4724	270	12.176	2.473	14.05	4820	144	6.1408	2.459	13.97	7303	210	10.7348	1.419	8.06
4702	272	12.480	2.232	12.74	4817	150	5.2002	2.002	11.47	7308	218	10.5668	1.547	8.79
4720	278	11.401	1.866	10.60	4823	151	5.6950	1.321	7.50	7314	219	11.4692	1.725	9.80
4716	281	13.061	1.889	10.73	4808	152	6.4767	1.794	10.19	7309	229	12.5288	1.779	10.10
4709	290	12.004	1.824	10.36	4806	155	6.9606	1.595	9.06	7312	245	10.7326	1.954	11.10
4713	294	12.054	1.907	10.59	4822	157	6.6148	2.696	15.31	7321	261	12.9620	2.415	13.72
4719	295	11.897	1.476	8.38	4811	159	6.3916	2.417	13.73	7313	284	12.1798	2.499	14.19
4705	296	12.274	2.614	9.03	4824	166	5.9324	2.109	11.98	7307	306	13.173	2.362	13.45
4712	299	13.104	2.485	14.12	4812	176	8.2980	1.722	9.78	7319	325	13.9718	2.312	13.13
4717	303	12.536	1.597	9.07	4807	182	8.6880	2.069	11.75	7306	338	13.0815	1.629	9.25
4715	304	13.003	1.995	11.33	4805	187	8.5149	1.830	10.39	7304	0	8.9246	1.946	11.05
4710	325	13.825	1.931	10.97	4815	196	8.9176	1.928	10.95	7305	0	7.7959	1.821	10.34
4708	347	13.850	2.141	12.16	4825	203	7.1600	1.979	11.24					
4714	376	18.074	2.010	11.42	4803	206	6.7236	2.133	12.12					
4706	412	17.819	2.856	16.22	4804	206	9.5090	1.770	10.05					
4703	539	24.388	1.254	7.12	4802	232	7.5580	1.713	9.73					
4725	555	24.672	1.432	8.13	4801	257	1.9516	1.704	9.68					
Average	309	13.433	2.064	11.49	Average	163	6.7224	1.936	11.00	Average	244	10.0967	1.9178	10.89

The effect of seasonal differences in the grain would require a series of analyses covering a longer period than is here represented, but it is generally regarded that these do have a greater or less effect in causing a fluctuation of the entire mass for any one season as compared with another. Below are presented averages of the previously stated analyses separated according to the years in which they were grown.

TABLE XVI.—AVERAGE COMPOSITION AS AFFECTED BY SEASON.

	Australian.		Club.		Bluestem.	
	1904.	1905.	1904.	1905.	1904.	1905.
Number kernels in 10 grams	287	283	342	297	281	280
Relative hardness of kernel	286	327	212	222	249	328
Moisture	11.71	12.42	11.86	12.13	11.81	11.62
Total protein	10.38	8.90	9.43	9.36	10.47	9.12
Gliadin	3.95	3.19	3.59	3.13	4.05	3.00
Glutenin	4.58	4.08	3.96	4.71	4.23	4.70
Gluten	8.53	7.27	7.55	7.84	8.28	7.70
Non-gluten protein	1.85	1.63	1.88	1.52	2.18	1.41
Carbohydrates and fat	87.42	89.08	88.58	88.72	87.47	88.93
Ash	2.00	2.02	1.99	1.92	2.06	1.95

It appears from these averages that the season of 1904 had a tendency to produce a smaller kernel, and one of somewhat higher total protein than did the season of 1905, and that this was also true so far as the gliadin was concerned, but that it does not hold with reference to true gluten.

It is undoubtedly true that should the season be such as to seriously arrest the development of the grain, and thus produce a pinched kernel, then it results in a markedly higher gluten as well as gliadin content. This is shown in the analyses of a considerable number (82) of pinched wheat samples grown in the same years as the samples given above, the results of which analyses are stated in Table XVII.

TABLE XVII.—SHOWING AVERAGE COMPOSITION OF PINCHED WHITE WHEATS.

Name.	Kernels in 10 grams.	Moisture.	Chemical analysis. Calculated to dry matter.							
			Gluten.						Non-gluten protein.	Ash.
			Total protein.	Gliadin.		Glutenin.		Total per cent of wheat.		
				Per cent wheat.	Per cent total protein.	Per cent wheat.	Per cent total protein.			
Club (46)	405	12.28	9.79	3.88	39.63	4.33	44.23	8.21	1.56	2.11
Australian (17)	341	11.59	11.78	4.83	41.00	4.95	42.02	9.78	2.00	2.12
Bluestem (13)	366	12.18	10.60	3.85	35.27	4.96	47.84	8.81	1.97	2.02
Sonora (6)	442	12.12	9.62	3.68	38.23	3.76	39.08	7.44	2.18	2.08
Average (82)	388	12.04	10.45	4.06	38.5	4.50	43.8	8.56	1.89	2.08

MILLING TESTS.

The flour used in making our ordinary bread is the white portion called the endosperm separated from the remainder of the kernel. The whole aim of the miller is to get as large a portion of this white material free from the dust hairs and small particles of bran (cuticle, episperm, tegumen (?) and embryonic membrane taken together), and other undesirable products which impair the color, odor or quality of the flour.

To-day there are probably more differences in mills and methods of milling than ever. To mill all the different kinds of wheat and mill them to the best advantage into the different products for which each wheat is best adapted, slightly different processes must be employed. and millers do not agree as to the best method for obtaining certain ends, nor do they seem to think it urgent that a standard by which they mill should be adopted. Some agitation has been started, however, and it is hoped that some satisfactory standard may be found. As the situation now stands, every miller makes his own standard and determines the quality of his brand, and to the purchaser the name is meaningless.

As stated above, the aim of the miller is to obtain the largest possible yield of clear white flour. This is accomplished by screening, scouring, fanning, and washing the wheat, as may be deemed necessary, before grinding it. Washing is very necessary with California grown wheats since they are not as clean as eastern grown ones. Then, too, the native wheat is harvested and immediately bagged, in which condition it stays until it reaches the mill. Not only do they contain the dry dust from the dry summer fields, but also smut and bunt as well as a goodly supply of grasshopper segments; and the aroma, after two, three or more months, penetrates the seed to such an extent that it is noticeable for some time after it is emptied from the bags. Eastern dealers in grain rarely, if ever, find this condition, but instead have "musty grain" which is caused by dampness. Aeration greatly improves musty wheats, and the same process would improve the above-stated condition in California.

Having cleaned the wheat properly, it is put through a series of two to six corrugated rolls and five to eight sets of smooth rolls, the number of each varying with the process used. Between each set of rolls the middlings are sized and separated into a varying number of streams, so that every set of rolls furnishes a stream to every following set as well as some portion of finished product. The total number of streams produced depends entirely upon the method of sifting and bolting.

The corrugated rolls are primarily for loosening dust, hairs, and the outer portion of bran layer. No attempt is made at grinding, but only at cracking. In this process some of the particles of flour are lost, and this, with the dust and other loose particles, constitutes the low-grade flours. The amounts lost in this operation depend upon the condition and quality of wheat and also upon the skill of the miller.

After the removal of the low-grade flour and the bran portion, the remainder of the process is the purification and reduction of the middlings into the higher grades of flour. Since the portion near the bran has a higher per cent. of gluten than the center of the grain, it is obvious that, for a flour with high gluten content, the milling must be as complete as possible and since the central portion is the first to be reduced because it is softer, and unprotected after the grain is split, the flour from the first breaks contains less gluten than that from later reductions. While the product from the last rolls is richest in total protein, it is also contaminated with particles of bran and a small amount of germ, which lower the color and quality of the flour so it can not be included in the patent grades, but rather in the clear or bakers' grade.

Method Pursued.—The preparation of the flour was made on a small experimental mill with two sets of rolls, one with medium corrugations and the other smooth. The sifting was done in an attached frame carrying three separate bolting cloths or wire sieves, as was necessary. This frame was completely enclosed, and the pan for receiving the flour was boxed under the platform, the flour being conducted from the shaker through an opening in the platform into the pan by a canvas stocking so as to reduce the loss from dusting to a minimum.

BRAN, SHORTS, AND FLOUR.

The terms flour, shorts, and bran are rather flexible terms, and hardly capable of exact definition, and for this reason many regard the stated yield of flour as having relatively small value, yet, where the tests are made with some degree of uniformity, the mill not being forced, and only that portion of the possible flour being put into the "straight" product, which can be so done without reducing the color standard, it should convey a meaning of relative value. It is, of course, perfectly easy to make seventy per cent. or more of straight flour from even the lowest grades of wheat, provided the term be employed in a sufficiently broad sense to include all that can be obtained from the wheat, and a little more grinding will always bring a little more of the bran into the shorts. For the above reasons the proportions of products obtained by different operators may seem to vary quite widely, and the same variation occurs in the commercial products, particularly in what is commonly called "patent flour," which is largely dependent upon the flexibility of the manufacturer's conscience.

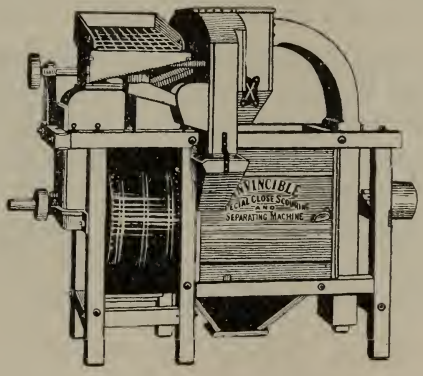


FIG. 14.—Showing small grain scourer used in these experiments.

In these experiments, before grinding, the samples were cleaned as thoroughly as possible by screening and passing them through a small sized "Invincible" scourer designed to remove all dust particles and the brush upon the ends of the kernels. The varieties all being "soft" wheat, it was not deemed necessary to "temper" them with water, as is frequently done. Ordinarily, the grain was subjected to two reductions upon the corrugated rolls, although in a few cases a third was deemed necessary. The middlings were usually reduced in three operations, more were required in a few instances.

Flour.—Since only a "straight grade" flour could be made, the material was all passed through a No. 10 bolting silk, and care was taken to include in this all the material which seemed by its color to be fit for the making of fair quality of bread. To unify the product it

was now passed through a No. 11 bolting silk, and all that passed this silk was termed *flour*. The part retained on this gauze, when judged to be clean, was termed "low grade." The flour from the first break was not dark enough to be necessarily put into the low grade class.

Bran.—The portion of the chop retained on a 2 mm. mesh wire sieve was termed "bran."

Shorts.—The "shorts" was separated from the middlings by a No. 50 and a No. 70 grit gauze, the former being used in the first and the latter in the last two separations.

In each case a kilogram was taken as the basis for milling. The yield of mill products is stated in the subjoined table, which also states the bushel weight, the condition of the berry, and the relative "commercial

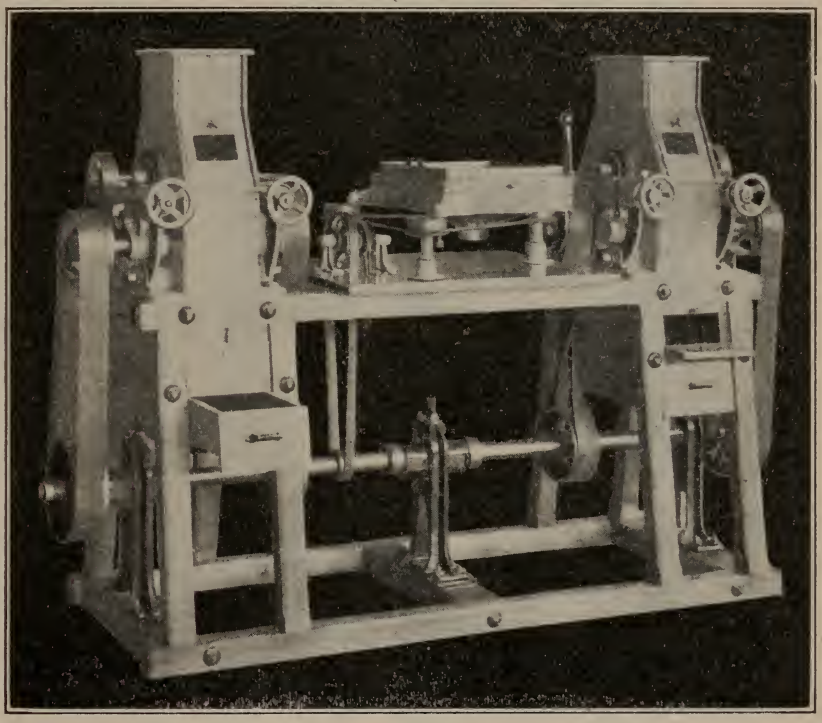


FIG. 15.—Small Allis-Chalmers mill used in these experiments.

grading," which latter was obtained by taking the average of the grades placed upon the samples by the "official" grain inspector of the Merchants' Exchange and that of one of the well known millers of the State, on the basis of the terms "choice milling," "good milling," "fair milling," and "poor milling," and allowing a difference between each term of 2.5 points, choice milling being rated as 100. The loss due to dusting and arising from transfers of material ranging from zero to three per cent., is likely to belong mostly to the flour and for the sake of uniformity has been so returned (?).

Not much difference could be noticed in the reduction of the various samples. The relative hardness of some could easily be recognized, especially if two samples with extremes of hardness were ground one after the other. There was an appreciable difference in the bolting of the same. Some of the Club samples, as millers generally recognize, required more time to obtain the same separation, but some also bolted as readily as either Bluestem or Australian.

TABLE XVIII.—YIELD OF MILL PRODUCTS.

White Australian.

Laboratory number.	Bushel weight, pounds.	Condition of berry.	Relative grading.	Bran, per cent.	Shorts, per cent.	Flour.		Loss.
						Straight.	Low grade.	
231	63.0	Plump	100.0	18.0	11.5	69.0	2.0	.5
288	62.5	Plump	100.0	18.0	9.5	70.5	2.0	.5
304	62.5	Plump	100.0	16.0	14.0	68.0	2.0	.0
311	61.0	Plump	100.0	16.5	13.5	68.0	2.0	2.0
184	60.5	Sl. pinched	100.0	16.5	12.9	68.7	1.9	.8
23a	61.0	Plump	100.0	16.5	11.0	70.0	2.0	2.0
322	60.5	Plump	100.0	15.5	12.0	70.5	2.0	.5
326	61.0	Plump	100.0	17.0	12.5	68.5	2.0	1.0
232	59.5	Plump	100.0	17.0	12.5	69.0	1.5	.0
383	62.0	Plump	98.7	18.0	12.0	68.0	2.0	1.5
62a	58.9	Plump	98.7	15.5	12.5	70.0	2.0	1.0
319	59.5	Plump	97.5	16.0	13.0	68.5	2.5	.5
309	59.5	Plump	97.5	16.0	13.5	68.5	2.0	.5
41a	56.1	Pinched	97.5	15.5	16.5	66.0	2.0	1.0
310	58.0	Plump	96.7	16.0	14.5	67.5	2.0	1.0
312	58.0	Plump	96.7	18.0	11.5	68.5	2.0	1.0
35	57.5	Pinched	96.7	16.5	13.5	68.5	1.5	1.0
275	59.0	Plump	92.5	16.0	13.5	68.0	2.0	.0
	63.0	Maximum	100.0	18.0	16.5	70.5	2.5	2.0
	56.1	Minimum	92.5	15.5	9.5	66.0	1.5	.0
	60.0	Average	0.0	16.6	12.8	68.7	1.9	.9

Washington Bluestem.

303	62.0	Plump	100.0	16.5	10.5	70.5	2.5	2.5
17	61.0	Plump	100.0	17.0	12.0	69.0	2.0	3.0
268	60.0	Plump	100.0	16.0	12.0	70.5	1.5	.5
205	60.7	Plump	98.7	19.0	9.0	70.0	2.0	.0
299	59.0	Sl. pinched	98.7	16.5	13.0	68.5	2.0	.5
262	60.0	Pinched	98.7	15.5	13.5	69.0	2.0	.5
19a	59.0	Sl. pinched	98.7	15.5	14.0	67.5	2.0	.5
15a	59.3	Plump	98.7	16.0	14.5	67.5	2.0	3.5
272	59.5	Sl. pinched	98.7	17.0	11.5	69.5	2.0	.5
212	60.0	Sl. pinched	97.5	16.0	12.0	70.0	2.0	2.0
267	59.5	Sl. pinched	97.5	15.0	13.0	70.0	2.0	.0
10a	58.5	Plump	97.5	16.5	12.5	69.0	2.0	.5
386	58.8	Plump	96.7	18.0	13.0	66.5	2.5	1.5
302	58.0	M. pinched	95.0	17.5	13.5	67.0	2.0	.5
206	58.0	Sl. pinched	93.7	19.0	15.0	64.0	2.0	2.0
208	57.2	M. pinched	90.0	17.0	14.0	67.0	2.0	2.0
300	56.5	Plump	93.7	18.0	13.0	67.0	2.0	1.0
	62.0	Maximum	100.0	19.0	14.5	70.5	2.5	3.5
	56.5	Minimum	90.0	15.0	9.0	64.0	1.5	.0
	59.3	Average	0.0	16.8	12.7	68.5	2.0	1.3

Little Club.

Laboratory number	Bushel weight, pounds.	Condition of berry.	Relative grading.	Bran, per cent.	Shorts, per cent.	Flour.		Loss.
						Straight.	Low grade.	
163	60.5	Sl. pinched	97.5	15.0	14.5	68.0	2.0	2.5
233	61.7	Pinched	97.5	16.5	14.0	67.5	2.0	1.5
266	60.0	Plump	96.7	16.5	12.0	69.5	2.0	.0
253	59.0	Plump	96.7	18.0	12.5	67.5	2.0	.0
28a	57.5	Plump	96.7	14.5	13.5	70.5	1.5	1.5
313	58.0	Sl. pinched	95.0	17.0	12.0	69.0	2.0	.5
179	60.2	Sl. pinched	95.0	17.0	14.5	66.5	2.0	2.5
51a	58.5	Sl. pinched	95.0	16.0	14.0	68.5	1.5	1.0
185	60.0	Sl. pinched	93.7	16.0	15.0	66.5	2.5	.5
317	59.4	Plump	93.7	16.5	12.0	70.0	1.5	1.0
277	57.5	Plump	93.7	15.0	14.5	67.5	3.0	1.5
305	59.5	Plump	93.7	17.0	13.0	68.0	2.0	.5
169	60.0	M. pinched	93.7	18.0	14.0	66.5	1.5	.0
50a	58.5	Plump	93.7	16.0	12.5	69.5	2.0	.0
315	59.0	Plump	92.5	17.0	13.0	68.0	2.0	.5
270	54.5	Pinched	92.3	18.0	12.0	69.0	1.5	1.0
247	54.0	Sl. pinched	92.5	19.0	14.0	65.5	1.5	.0
290	57.8	Sl. pinched	92.5	17.5	14.0	67.0	1.5	2.5
316	55.0	Pinched	90.0	17.0	11.5	69.5	2.0	.5
		Sonora.						
481	66.0	Plump	100.0	11.0	20.0	66.0	3.0	2.0
254	63.7	Plump	98.7	16.0	13.0	69.0	2.0	1.0
74	63.0	Plump	97.5	9.0	20.5	68.5	2.0	2.5
249	62.8	Plump	97.5	15.5	14.0	68.5	2.0	1.5
257	58.7	Plump	96.2	16.0	16.5	65.0	2.5	2.5
248	59.0	Sl. pinched	85.0	19.0	14.0	65.0	2.0	1.0
		Propo.						
468	62.8	Plump	100.0	16.0	12.5	69.0	2.5	2.5
225	57.0	Sl. pinched	95.0	11.0	23.0	64.0	2.0	.5
226	53.0	Pinched	90.0	15.5	20.0	61.5	3.0	1.5

Examining the columns recording the flour yield, there appears but small difference in the flour yielding power of the three principal wheats, with the White Australian in the lead, the average yield being 68.7 per cent. for the White Australian, 68.5 per cent. for the Bluestem, 68.2 per cent. for the Club, and 67.0 per cent. for the small-grained Sonora.

The greatest difference in flour yield is seen to be 8 per cent. This occurs between samples No. 206, which yielded only 62 per cent. and several samples each yielding 70 per cent. Number 206 is a fairly plump sample, but the kernels are not dense and the weight per bushel is only 58 pounds, while those samples which yielded 70 per cent. flour averaged about 61 pounds per bushel. It does not follow, however, as may be inferred, that those wheats weighing heaviest invariably yield the largest amount of flour.

In the yields of bran and shorts, the average amount obtained is about 30 per cent. of the whole wheat. The Sonora wheat, on account

of its smaller size, giving a larger proportion of surface, yields a larger percentage amount of these constituents. The bran coat is actually thinner on this type than on the other three, so that if the kernels were as large as those or Bluestem it would undoubtedly give larger flour yields.

THE BAKING VALUE OF A FLOUR.

In deciding upon the baking value of a flour there are three points which demand particular consideration, viz., the color, the gluten content, and the strength, or absorption capacity, all of which points must be satisfactory in a flour of the best quality for baking. A chemical analysis alone of a flour tells very little of direct value to a baker, as it does not necessarily indicate the character of the loaf which that flour will produce, but if the baker knows the gluten content, the strength, and the color, he can form a fairly accurate idea as to how the flour will act in baking. In addition to the above, there are certain other characteristics which act as aids in enabling one to have a better understanding of a flour. In general, it may be said that there are two classes of flours as to their effect upon the touch. One type may be described as granular, hard, or lively. It may be poured from one vessel to another with comparative ease, and is somewhat suggestive of an extremely fine sand. The other type is usually referred to in contradistinction as soft, velvety, or smooth. It is this latter type that is obtained from the milling of the soft white wheats here under discussion. Relatively speaking, the latter type is considered weaker than the former in bread value, but better adapted to pastry, biscuits, etc. This, however, is not without frequent exception, as very often soft wheat flours may be found to have excellent baking value even when made without blending, as will be seen in the tabulation later.

Color.—One of the most important characteristics of a good flour is its color. While mere color is of no direct benefit, it is a property much desired, and one by which the relative merits of flours are judged to a large extent by millers, brokers, and housewives alike. The color depends largely upon the mechanical composition of the flour. The poorer the process of milling the larger the amount of foreign particles which give a darker color. High moisture usually has a darkening effect. The color of the gluten is also effective in varying the color of the flour.

California wheat produces a very white flour on account of it being very starchy and having a small amount of gluten, which is not so highly colored as in other wheat flours. They have little of that creamy color so characteristic of eastern flours. There are some, however, that are quite as yellow, and in the Sonora flours examined some had considerably more yellow tint than the eastern flour used for a standard of comparison.

In the washed glutens the color is more noticeably variable than in the flour. For the most part these glutens are blue gray. Occasionally there is a creamy one; generally the creamy-colored flour gives a creamy gluten, but a creamy-colored gluten need not follow from a creamy flour. The Sonoras invariably yielded creamy glutens. The whitest flours do not necessarily produce the whitest loaves. In no case does the color of the bread hold the same relative position in the loaves as the color of the flour. In a general way, all tinted flours are a little darker relatively when baked, as their color value does not increase. The yellow-tinted flours appear to change their relative value more markedly.

The color, however, has no real relation to the baking or nutritive value, and, as may be inferred from what has been said, is not a very reliable guide as to the color of the resulting loaf, although it generally holds that gray flour produces a dirty-colored loaf, and that, inasmuch as a yellow flour usually indicates a high gluten content, they usually show less loss in the oven and therefore have a better bread value, and do not necessarily produce a darker loaf.

The matter of color, while it certainly does affect the commercial value of a flour, is a decidedly sentimental factor. It is also noticed that those flours which enhance their color value in the process of baking show a slightly lower loss in the oven. A high color value is quite commonly associated with low gluten and low strength.

The amount and quality of gluten also have their effect on the color of the bread. Those flours with a low quality of gluten, and especially if the gluten is rather dark, produce bread that appears uneven in color. This is due to the breaking and massing of the gluten, thereby making uniform distribution of the gases impossible, and preventing uniformity in color.

In carrying this comparison to the dough, it is seen that the same relation invariably holds. The color value of flours from this class of wheats is high both in the dough and in the flour. The relative color value between the flour and the dough made from it is not expressed in the table, because of the lack of a satisfactory method of definite statement of this factor, but the dough is always relatively darker than the flour from which it is made.

As to the relative color of the breads, it is the same as in the dough and flour with the exception that the yellow Sonora flour has baked whiter than the Club flour, which is probably another reason why millers do not like Club wheats.

On account of lack of time and the somewhat mixed conditions of these commercial wheats, no attempt was made to subject them all to either milling or baking tests, but instead selections were made to represent as wide a range of condition as possible. Owing then to the com-

paratively small number of samples baked, no attempt will be made to formulate definite statements to be applied to the several varieties when the samples are pure. This must come from a later study now in progress in which the varieties are of known purity. An inspection of the table, however, shows a number of interesting points which will next be discussed.

Inasmuch as the calculation to dry matter would not change the relative position of the samples in any case, the results are stated on the basis of the original condition of the material.

Moisture.—As in the case of wheat, the moisture content of flour is largely determined by the atmospheric conditions under which it is stored. Around the bay sections of the State, flours would show a much larger percentage of moisture than would those of the same grade in the interior, and likewise their absorption capacity, or strength, would be somewhat lessened, provided the gluten content remains the same. From a commercial standpoint the question of moisture is as important in the case of flour as in that of wheats mentioned earlier in this bulletin. A large profit it undoubtedly brought to dealers through the influence of this factor alone.

As might be expected, the moisture content of the flour is invariably higher than that of its corresponding wheat.

The maximum moisture content shown in any of these flours was 14.13 per cent. and the minimum 11.32 per cent., with a general average of 13.57 per cent. for all the flours examined. These are very high figures as compared with those from Canadian flours, which are reported as carrying from 9 to 10 per cent, and Minnesota flours which carry about 12 per cent. In no case did the moisture content fall as low as those indicated for the Canadian flours, and in three instances it rose above 14 per cent.

To a certain extent this difference in moisture will account for the difference in the amount of bread that can be made from flours produced in those sections as compared with the Coast flours. This same will undoubtedly apply to flours in the interior of the State as compared with those in the coast section. For the bread maker this is quite an important matter, since, other things being equal, the drier the flour the greater the weight of bread that can be made from it.

Nitrogenous Compounds.—It was observed in the case of wheat that the total per cent. of proteids was low. The average protein content of the wheat milled was 8.57 per cent. and the average of the flours milled from them was 7.03 per cent; or about 82 per cent. of the total protein of the wheat passed into the flour. Quite generally the amount of proteids found in flour depends upon the amount contained in the wheat, though it does not follow in every case that the wheat with the

highest proteid content yields a flour with the highest percentage of proteids.

Total Protein.—In the matter of total protein the flours take the following rank: Propo, 7.83 per cent.; White Australian, 6.73 per cent; Bluestem, 6.61 per cent; Little Club, 6.59 per cent; Sonora, 6.39 per cent, the general average being 7.03 per cent.

As to the proportion of protein which passed into the flour in each variety the following will show the relation by varieties:

White Australian	80.2
Bluestem	79.4
Little Club	84.4
Sonora	85.1

Gluten.—The nature of gluten has already been discussed in the earlier pages of this bulletin and need not be repeated here. The percentages set forth in the table refer only to the chemically determined gluten consisting of the gliadin plus the glutenin.

Considering the relation of gluten to total proteids in wheats and their corresponding flour, the average relation is as follows:

	Wheats.	Flours.
White Australian	83.9	96.1
Bluestem	82.6	97.1
Little Club	77.0	98.6
Propo	---	98.8
Sonora	81.7	93.1

The relation of gluten proteids to the total proteids is very different in these flours from that existing in the common wheats of the Middle West. Snyder has stated that the best bread-making qualities of a flour obtain when the gluten proteids are about 85 per cent. of the total proteids. If this is also true of the soft wheats then we may attribute a poor quality of our flour in part at least to the unbalanced relation of gluten to the total proteids. The averages for each type namely, Bluestem, 97 per cent; Club, 97 per cent; Australian, 95 per cent.; Sonora, 95 per cent.; show how far different this relation is from that found in eastern wheat.

The quantitative, wet-gluten determination was carried through with a considerable number of the flours, but the results, as compared with the chemical determinations, were so inconsistent that they will not be given.

The wet gluten as determined was in each case dried and the per cent. of dry gluten determined. These figures are fairly consistent and reliable. Subtracting the percentage of dry gluten from 100 gave the per cent. of moisture held by the gluten. The range of variation was from 53.3 per cent. to 64.3 per cent. (?) The relation between the moisture content and the expansions made on the gluten are fairly constant on averages. The higher the amount of moisture retained by the wet gluten the larger the expansion. In a general way the expansion

fluctuates with the amount of gluten. There are certain distinctive characteristics of these soft white-wheat glutens which are of interest at this point.

The gluten test as quite generally made where flour is studied is not at all satisfactory when applied to soft wheat flours. The first difficulty encountered in its application is the small amount of the proteids contained in the flour. In attempting to wash a flour with a low gluten content, the proportion of gluten is so small that it makes it almost impossible to get the fine particles into contact before many are carried away with the water.

WASHED GLUTEN TESTS NOT RELIABLE.

The nature of the gluten is a second difficulty. It acts entirely different in the hand from eastern flours. The first difference is noticed in the dough; a soft wheat dough can be distinguished very easily, especially if not of the best quality, by its being perfectly smooth on the surface after the dough has been worked and is ready for washing. The standard dough is soft and spongy, while the soft wheat dough is firmer and more tenacious, and works very much like a soft putty. The dough on being worked has a marked tendency to stick to the hands and the utensils. The standard dough, while also having that quality, does not have it to the same degree. The two doughs differ much in this respect, that, while they are both tenacious, the standard dough is very cohesive and will not permit its body to separate while the soft wheat dough will in nearly all cases. Of the total fifty-eight doughs made, only three or four approximated the standard in their handling qualities.

The next noticeable feature these doughs present is in the surface of the doughs when placed side by side. The poorer dough has the smoother surface. The better the quality of the gluten the more uneven is the surface. There are no abrupt grooves or ridges upon it, but there are small, circular, uneven, bullet-like prominences. The further in the process this dough goes the more pronounced this becomes. They are especially noticeable in kneading the dough back the second or third time. On a poor-gluten flour this structure is never seen, not even in kneading back. The more a dough is worked after raising, the less noticeable these irregularities become. Their appearance on the dough, after making the water-absorption test, generally gives a very fair idea of what is to be expected in the volume of the loaf.

In washing a poor and a good quality of gluten from flour there appears again an indication of the relative qualities of the good gluten dough, the gluten masses appear distinct, even from the very beginning, and they are much more apt to stick to the dough ball than to the hands. The standard never sticks to the hands. The particles may occasionally be separated from the mass, but not so often as those from the poorer gluten doughs. On washing a dough of inferior quality the

gluten masses do not appear as soon; when they do become visible, they are not distinct and clean, but mixed with more starchy paste. This will stick to the hands and apparently has little affinity for the ball of dough. The very poorest doughs will go to pieces in the process, and always tend to form a paste rather than a separation, and it makes little, if any, difference even though the wash water be used drop by drop. A good washed gluten will be firm and very much like gristle at first, but will work down after awhile to a very elastic and well-mixed mass. The gluten of poor quality will be soft and indifferent, and soon works into a smooth, soft mass that has little recoiling ability, and when placed upon a cardboard to dry, if it is not dried at once, it is very likely to run all over the cardboard, thus showing its low strength.

Considering the mechanical separation of gluten, as applied to the soft or white wheat flour, it is not satisfactory, as stated before. In the most troublesome instances only about one half of the amount was recovered. This leads to the belief that perhaps some of the proteids of these wheats are partly soluble in water and are washed away, thus adding to the mechanical loss. Some flour was set for four hours in cold water, filtered, and the nitrogen in the filtrate determined, with the result that from 12.48 to 17.90 per cent. of the total proteids were found water-soluble. As was previously stated, about 97 per cent. of the total proteids in flour are in the form of gluten. Therefore, some of the gluten amounting to the difference in these two percentages must be soluble in water. The alcohol extraction of the residue showed that from 25 per cent. to 58 per cent. of the gliadin was removed. From samples containing small and large amounts of gluten, the total amount of soluble proteids is larger in the high gluten flours and gradually falls as the gluten content decreases. The decrease in the soluble proteids is not as rapid as in the gluten content, so that the percentage amount of soluble proteids to the total amount of proteids gradually increases and is highest on the flour with the lowest total proteids, thus tending to concentrate the error in the method upon the poorer grade of flour.

Gliadin.—Gliadin has been given much consideration in most discussions of flour. It seems hardly worthy of so much stress as has been given it, especially as regards the white wheats. The gliadin is said to impart the tenacity and adhesiveness to the gluten. While this may be largely true, it does not seem to apply so generally to the white wheats. The total average of gluten in the form of gliadin is less than 50 per cent. The standard contains 53 per cent., which is lower than is usually found in eastern spring wheat flours.

There is a very decided difference in the tenacity of the average California flour gluten and the standard; the Californian being the more tenacious and very soft, and still has the lower amount of gliadin, not

only as figured on the gluten, but those that are figured to the total amount of proteids, and contain a lower percentage than the standard on the same basis.

An examination of the table shows that in nearly every case the gliadin content of the flour is higher than that of its corresponding wheat, and that this difference is much more marked in the wheats carrying the larger per cent. of protein.

While the gliadin increases towards the outside of the kernel, there are some instances in which the reverse appears true, which may be inferred from the lower percentage of gliadin in the flour than in the wheat. In one sample the gliadin-number in the wheat and in the flour remains the same. Since all of these percentages are found, they would suggest that variations in every way in the distribution of the gliadin in the grain do occur. The data is, however, insufficient to fully establish this as a fact.

Gliadin-Number.—By the gliadin-number is meant the percentage which the gliadin is of the total protein.

In most cases the gliadin-number is increased in milling, that is, the flour shows a larger percentage of gliadin than the corresponding wheat, thus showing the wheat to carry a larger percentage of gliadin in the inner portion of the grain. The average gliadin-number for these samples was 48.6 for the flours as against 33.4 for the wheats, or an average increase of about 4 per cent. by milling.

The range in gliadin-numbers was between 34.2 in No. 268 and 69.3 in 41*a*. Considering the matter by varieties Propo leads with 51.6. Were the gliadin-number the only factor which should be considered in relation to the baking value, or even the determining factor, then Little Club flour with an average of 51.6 should stand close to Propo, but that this is not so is not only the common experience, but is also shown in the fact that the average volume of the Club loaves was only 76 cubic inches as against 83 and 85 cubic inches, respectively, for White Australian and Bluestem.

That the effect of gliadin ratio may often be overshadowed by the total amount of gluten is clearly shown by a series of bakings made from flour having the same gliadin ratio (50:50), but a varying total gluten content.

The gluten content of the flour and the volume of each resulting loaf is shown below. The series of loaves is shown in Figure No. 16.

No.	Gluten.	Volume.
8	10.11	97 cu. in.
9	9.37	87 cu. in.
10	6.92	83 cu. in.
11	5.50	66 cu. in.
12	4.70	61 cu. in.

Here it may be seen that notwithstanding there is the same gliadin-number the volume of loaf follows the order of the total protein.

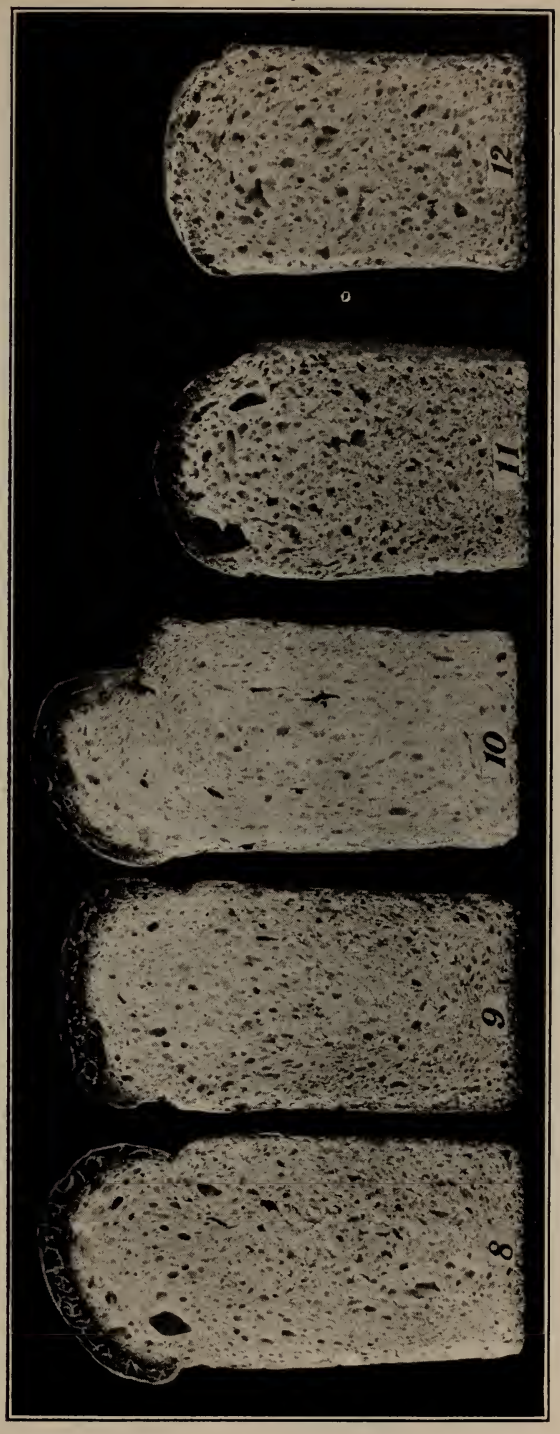


FIG. 16.—Showing effect of protein content on volume of loaf, the gliadin ratio remaining the same.

TABLE XIX.—SHOWING CHEMICAL CHARACTERISTICS OF WHITE WHEATS AND THE RESULTING FLOURS AND ALSO THE BAKING VALUE OF THE FLOURS.

White Australian.

Number.	Original wheat.								Corresponding flour.								Absorption	Loss in baking, per cent.	Weight of loaf	Volume of loaf, cubic inches	Loaves per barrel
	Moisture	Total protein	Gluten. Gliadin	Gluten. Glutenin	Total gluten	Gliadin number	Non-gluten protein	Ash	Moisture	Total protein	Gluten. Gliadin	Gluten. Glutenin	Total gluten	Gliadin number	Non-gluten protein	Ash					
62a	11.87	9.64	3.43	4.75	8.18	35.6	------	1.83	13.02	7.97	4.15	3.54	7.69	52.1	.28	.47	51.5	13.0	46.9	90	270
41a	11.38	11.72	4.23	5.61	9.84	36.1	1.88	1.64	13.04	7.80	5.42	1.86	7.28	69.3	.52	.55	53.8	12.1	48.0	88	276
304	8.88	9.25	2.95	4.54	8.22	31.9	1.76	1.81	12.67	7.47	3.47	3.40	6.87	46.4	.60	.52	51.2	11.9	47.6	84	274
251	12.54	8.46	2.24	4.84	7.10	26.5	1.36	1.74	13.72	7.02	3.34	3.55	6.89	50.6	.13	.49	49.1	14.0	45.2	82	260
320	12.09	8.70	2.63	4.71	7.34	30.2	1.36	1.65	13.74	6.96	3.15	3.68	6.83	45.3	.13	.43	47.9	6.0	49.7	89	286
231	12.18	6.78	2.15	3.44	5.59	31.7	.52	1.69	13.05	5.86	2.33	3.41	5.74	39.8	.12	.45	52.9	8.7	49.9	78	287
232	12.54	6.06	2.07	2.79	4.86	34.2	1.20	1.69	12.89	5.42	2.28	2.97	5.25	42.1	.17	.52	52.7	10.1	49.0	80	282
259	11.23	6.54	1.65	3.53	5.18	25.2	1.36	1.80	13.84	5.31	2.58	2.60	5.18	48.5	.13	.54	48.2	12.0	46.8	69	269
Average	10.34	8.39	2.67	4.37	7.04	31.8	1.35	1.73	13.24	6.73	3.34	3.13	6.47	49.3	.26	.49	50.9	10.9	47.9	83	275

Bluestem.

19a	13.68	9.64	3.07	5.17	8.24	31.9	1.40	1.65	12.43	8.62	4.31	3.90	8.21	50.0	.41	.57	52.4	11.2	48.4	92	278
196	9.18	9.25	3.30	4.59	7.89	35.7	1.36	1.79	13.39	8.14	2.80	4.96	7.76	34.4	.58	.48	50.0	13.4	45.5	86	262
25	12.64	12.12	4.07	6.18	10.25	50.9	1.10	1.78	12.64	7.88	4.23	3.42	7.65	53.7	.23	.43	52.9	13.0	47.6	93	274
17a	11.76	10.51	4.71	2.72	7.43	44.8	3.08	1.88	12.81	7.25	3.75	3.34	7.09	51.7	.18	.47	52.9	14.0	47.1	93	271
10a	11.89	7.72	2.55	3.85	6.40	33.0	1.32	1.75	12.72	7.08	4.43	2.42	6.85	62.6	.23	.54	52.4	12.0	47.6	81	274
289	14.30	7.97	2.24	4.37	6.61	28.1	1.36	1.60	14.02	6.74	3.58	3.03	6.61	53.1	.13	.52	47.6	11.0	46.8	88	269
299	9.44	7.32	2.83	3.13	5.96	38.7	1.36	1.76	13.65	6.62	2.67	3.83	6.50	40.3	.12	.36	51.4	11.0	48.1	79	282
386	12.18	8.37	2.71	4.34	8.03	32.3	1.32	1.42	13.12	6.38	2.51	3.81	6.32	39.4	.06	.43	51.8	11.2	48.2	85	277
303	9.68	8.41	2.87	4.39	7.20	34.1	1.76	1.48	13.87	5.99	2.83	2.03	5.86	47.1	.13	.43	53.8	13.6	47.2	87	272
325	12.34	7.47	2.25	3.86	6.11	30.1	1.36	1.65	13.53	5.71	2.95	2.63	5.58	51.5	.13	.41	46.8	13.0	45.9	79	264
260	13.07	6.78	1.67	3.75	5.42	24.6	1.36	1.70	13.80	5.27	2.40	2.74	5.14	45.5	.13	.72	40.7	12.0	46.4	83	267
272	13.06	6.22	1.94	3.30	5.24	30.2	.78	1.75	13.12	5.22	2.51	2.07	5.18	48.1	.04	.36	52.1	13.0	47.4	80	273
268	12.44	6.38	2.23	2.97	5.18	34.9	1.20	1.75	13.96	5.10	1.75	3.35	5.10	34.2	------	.42	51.8	6.7	49.6	76	285
Average	11.88	8.32	2.80	4.08	6.88	34.6	1.44	1.69	13.31	6.61	3.13	3.29	6.42	47.0	.19	.47	50.5	11.9	47.3	85	273

Little Club.

233	12.12	10.11	3.67	4.68	8.35	36.3	1.76	1.80	13.39	9.37	4.43	4.43	8.86	47.2	.51	.53	49.4	9.9	48.3	87	278
169	11.84	10.60	3.27	5.33	8.60	30.9	2.00	2.07	12.46	8.29	4.82	3.01	7.83	58.2	.46	.46	55.5	14.0	47.0	83	270
163	11.98	9.09	3.43	4.34	7.77	38.2	1.32	1.93	11.32	7.32	3.83	3.26	7.09	52.4	.23	.55	53.5	10.0	49.5	92	285
51a	11.77	8.13	2.55	4.42	6.97	31.4	1.14	1.92	13.13	6.54	3.27	3.15	6.42	49.8	.12	.44	51.8	12.6	47.4	89	273
317	11.09	7.25	2.63	3.14	5.77	36.3	1.48	1.79	13.96	5.02	2.67	2.23	4.90	54.9	.12	.43	50.3	7.9	49.6	71	285
266	12.48	6.46	2.23	3.07	5.30	34.5	1.16	1.73	13.80	4.94	2.47	2.35	4.82	50.1	.12	.44	52.1	9.4	49.3	63	283
253	12.90	6.54	2.31	2.99	5.30	35.3	1.24	1.92	13.82	4.71	2.27	2.44	4.71	48.1	------	.32	50.6	11.0	47.8	61	275
Average	12.03	8.31	2.87	3.53	6.40	34.7	1.44	1.87	13.13	6.59	3.39	3.02	6.41	51.5	.26	.45	51.9	10.7	48.9	76	278

Propo.

480	------	------	------	------	------	------	------	------	12.35	9.33	4.55	4.65	9.20	48.8	.13	.44	50.9	13.0	47.0	91	271
226	------	------	------	------	------	------	------	------	13.50	7.73	3.98	3.62	7.60	51.4	.13	.60	47.9	13.3	45.9	81	265
225	------	------	------	------	------	------	------	------	13.48	7.47	4.03	3.31	7.34	53.9	.13	.59	48.5	11.6	47.0	85	271
468	------	------	------	------	------	------	------	------	13.35	6.79	3.55	3.11	6.66	52.3	.13	.45	51.5	12.0	47.7	80	275
Average	------	------	------	------	------	------	------	------	13.42	7.83	4.03	3.67	7.70	51.6	.13	.52	49.7	12.5	46.9	84	270

Sonora.

481	12.45	8.77	2.95	4.22	7.27	33.6	1.50	1.60	13.03	7.49	3.72	3.77	7.49	49.7	------	.42	51.5	13.0	47.1	78	272
248	12.02	7.32	2.55	3.41	5.96	34.8	1.36	1.82	14.76	6.46	2.55	3.59	6.14	39.4	.32	.42	52.6	8.0	50.2	78	289
249	12.05	8.21	2.83	4.14	6.97	34.5	1.24	1.67	13.66	6.54	2.51	3.80	6.31	38.4	.23	.44	53.8	10.2	49.3	69	284
254	12.16	7.47	2.55	3.73	6.28	34.1	1.19	1.55	12.96	6.65	2.47	4.18	6.65	43.1	------	.47	54.4	11.7	48.8	77	281
228	12.53	6.86	1.98	3.52	5.50	28.9	1.36	1.70	13.41	6.00	2.47	3.53	6.00	41.3	------	.63	51.1	11.0	48.2	77	278
257	12.34	7.04	2.27	2.57	4.84	32.2	1.20	1.74	14.49	5.90	2.95	2.63	5.78	50.0	.12	.45	52.6	8.5	49.9	81	287
269	12.54	7.00	2.00	3.64	5.64	28.6	1.36	1.75	14.13	5.72	2.87	2.87	5.74	50.0	------	.52	48.5	13.0	46.2	77	266
Average	12.29	7.52	2.48	3.72	6.20	32.4	1.32	1.69	13.77	6.39	2.78	3.18	5.96	44.5	.23	.46	52.1	10.8	48.5	77	279

BAKING TESTS.

A number of the flours were subjected to a baking test to obtain a better knowledge of the actions of this class of wheat alone in the oven for the sake of comparison in later work.

The baking test furnishes the most accurate and reliable data as to the relative merits of flours. The bread is the ultimate product, no matter what has been indicated by previous tests. Though other tests usually assist much if given proper consideration and value in enabling one to establish right relations of flours; the baked bread is the one way in which all are able to judge of a flour value; the final test then is to decide which produces the better bread in large amounts.

THE METHODS.

The Strength or Water Absorption.—The strength of a flour is measured by its water-absorbing capacity in making a dough of given consistency. It is a factor which varies considerably with different flours even from the same variety of wheat. It is of much importance in determining the baking value of a flour.

The water-absorption of a flour, other things being equal, is indicative of the amount of gluten the flour contains and its quality. The larger the amount of the gluten or the better quality of the gluten, generally speaking, the more water it will take to make a dough of certain consistency. For bakers, a flour to which they can add a maximum amount of water and still have a loaf that will rise well and present an even texture and good color, is most desirable. The larger the amount of water absorbed by a flour, the more loaves can be produced per given weight of flour. Since the relation is a fairly constant one, the relative water-absorption number of flours compared is expressed, with other things, by the number of one-pound loaves produced per barrel of flour, provided the comparison is made under like conditions.

A peculiar quality very noticeable in all these flours is that of the dough becoming soft. There is constant danger of adding too much water; in this one feature the California flour differs from the standard flour as much as in any. Upon this depends the quality of the bread more than any other one factor. If there can be a reason given for this, it would be a long step towards explaining the whole difference between the Pacific coast flour and flour from the remainder of the continent.

The capacity of a flour for holding a large amount of water in the dough bears an approximate relation to the total per cent that the gluten protein bears to the total protein. The larger this percentage the more

water the flour will absorb. The relation also extends to the gliadin contained in the gluten. Two flours with the same percentage of gluten usually will require water according to the amount of gliadin contained.

The Method.—The water absorption or "strength," is determined by making a standard dough from a flour selected as a standard by adding a sufficient amount of water to give a dough of rather stiff consistency. This is about 17.5 cc. of water to 30 grams of flour for standard spring wheat flour, and 16.7 cc. for winter wheat flour, and 15.7 cc. for white wheat flour, when made to the same consistency, the exact amount of water required is noted. From this can be calculated the necessary amount of water for any given amount of flour. The amount here used was 340 grams of flour with from 161 to 189 cc. of water. To this was added 10 grams of fresh compressed yeast, 12 grams of sugar, 5 grams of salt, and a little lard. Two thirds of the flour was beaten up with the water for ten minutes, the remainder of the flour then added and the whole kneaded for ten minutes more. The yeast was previously added to the measured water and allowed to stand for fifteen minutes before being mixed with the flour. All utensils and apparatus were kept at about 95° Fahrenheit.

On removing the dough from the kneader it was made into two small loaves and weighed into a bread pan which was placed in an electric cupboard or expansion box at 95°F. Here it was allowed to rise for an hour and a half, re-kneaded and set again. When the dough had risen even with the top of the pan it was at once placed in an electric oven at 400–425° for thirty-five minutes. After cooling, the bread was weighed and its volume taken by placing the bread in a box of known volume. filling the unoccupied space with flaxseed, and measuring the seed required; the difference in the volume of seed and the volume of the box giving the volume of the loaf.

TABULATION AND CALCULATION OF RESULTS.

340 grams of flour used.
158 cc. water required for dough.
10 grams of yeast.
12 grams of sugar.
5 grams of salt.

525 grams of dough.

706 weight of pan and contained dough.
191 grams weight of pan.

515 grams of dough in the pan.

10 grams of dough left in the kneader.

515 grams of dough in pan.
488 grams of bread.

27 grams lost in baking.

27 is 5.2 per cent. of 515, or the per cent. of the weight baked out.

5.2 per cent. of 10 is .5 grams the loss on the 10 grams had it been baked.

27 grams given loss in baking.
.5 loss on 10 grams in the kneader.

27.5 loss on total dough.

525 grams of total dough.
27.5 grams loss in baking.

497.5 weight of loaf if all the dough were baked.
454.5 grams in a one-pound loaf.

43.0 grams overweight when calculated to a one-pound loaf.

A barrel of flour (196 pounds) equals 89,082 grams. When 340 grams are used per loaf there should be 262 loaves made from a barrel of flour.

43 times 262 equals 11,266 grams overweight produced in one barrel of flour.

454.5 grams equals one pound.
11266 divided by 454.5 equals 24 loaves in overweight.
262 loaves of 340 grams flour each in one barrel.
24 loaves gain in overweight.
286 loaves (weighing one pound) made from the tested flour.

Volume.—The volume of a loaf of bread is even more dependent upon the quality of the gluten than upon its quantity. After the pan of bread is placed in the oven, the high temperature increases the volume of the gas within the loaf, and also causes the formation of steam, which together tends to expand the dough. If the dough is coarse and not elastic, the gases escape through the pores into the oven, but if the gluten in the dough is of good quality it keeps these gases enclosed which cause the volume to increase.

If from Table XIX we select the results indicating the nine best loaves, as measured by their volume, arranging them in order and for the sake of contrast select and arrange the results from the poorest nine loaves we have some very interesting and suggestive data. (See Table XX.)

The general trend of results is clearly seen. Two unusual occurrences must be noticed. The first is the relation of the water holding capacity or absorption to the gluten content, and to the amount of gliadin to the gluten content. We would expect to find more difference in the absorption number than is shown, since the quality of the gluten is very evidently different, as is shown by the volume of the loaves. The second is the relation of the gluten and loaf volume to the number of loaves that may be produced from a barrel of flour. Ordinarily, we would expect the loaf production to increase with the amount and quality of the gluten. This would, probably, hold with flour of average to good quality, but with a poor flour, the loaf is coarser in texture and has a

smoother crust, and a smaller surface exposed, so that the loss between the weighing into the pan in which it is allowed to rise and the time it is baked may be considerably different. Then, too, the larger volume of the dough from good flour at the first kneading permits of much more water being carried off when the gases are worked out.

TABLE XX.—RESULTS OF BAKING TESTS.

Laboratory number.	Total protein.	Gluten.	Gluten, per cent of protein.	Gliadin.	Gliadin, per cent of gluten.	Gliadin number.	Absorption.	Loss in baking.	Volume of loaf, cubic inches.	Number laboratory loaves per barrel.
25	7.88	7.65	97.0	4.23	55.3	53.7	52.9	13.0	93	271
17a	7.25	7.09	97.8	3.75	52.9	51.7	52.9	14.0	93	274
163	7.32	7.09	96.9	3.83	54.0	52.4	53.5	10.0	92	285
19a	8.62	8.21	95.2	4.31	52.5	50.0	52.4	11.2	92	278
480	9.33	9.20	98.6	4.55	49.5	48.8	50.9	13.0	91	271
320	6.96	6.83	98.1	3.15	46.1	45.3	47.9	6.0	89	286
51a	6.54	6.42	98.2	3.27	50.9	49.8	51.8	12.6	89	273
41a	7.80	7.28	93.3	5.42	74.5	69.3	53.8	12.1	88	276
289	6.74	6.61	98.1	3.58	54.2	53.1	47.6	11.0	88	269
Average	7.64	7.38	97.0	4.01	54.4	52.7	51.5	11.4	90.5	276
253	4.71	4.71	10.0	2.27	48.1	48.1	50.6	11.0	61	275
266	4.94	4.82	97.6	2.47	51.2	50.1	52.1	9.4	63	283
259	5.31	5.18	97.6	2.58	49.8	48.5	48.2	12.0	69	269
249	6.54	6.31	96.5	2.51	39.8	38.4	53.8	10.2	69	284
317	5.02	4.90	97.6	2.67	54.5	53.2	50.3	7.9	71	285
268	5.10	5.10	100.	1.75	34.3	34.3	51.8	6.7	76	285
254	6.65	6.65	100.	2.47	37.1	37.1	54.4	11.7	77	281
228	6.00	6.00	100.	2.47	41.2	41.2	51.1	11.0	77	278
269	5.74	5.74	100.	2.87	50.0	50.0	48.5	8.5	81	287
Average	5.56	5.49	98.8	2.45	45.1	44.5	51.2	9.8	71.5	281

In Figure 17 (upper row) is shown the volume and character of loaves produced from certain flours of these wheats, No. 5 showing a loaf from a particularly good type of Little Club wheat flour from the crop of 1904, which gave a volume of 86 cubic inches; No. 7 made from a Sonora flour, also of the crop of 1904, but having a volume of only 76 cubic inches; No. 6 being from a Little Club flour, crop of 1905, and showing a volume of only 71 cubic inches.

In the lower row of the same plate are three illustrations showing that an increase of the gliadin ratio does not entirely govern the volume of loaf. The flours selected to show this had a widely varying gliadin number, but the gluten content was essentially the same, viz.:

Number.	Protein.	Gliadin number.	Volume.
268	5.10	34.66	76
272	5.22	48.52	82
317	5.02	54.65	71

FIG. 17.—Relation of volume to gliadin ratio.

First, the higher the gluten the larger the volume of loaf, other things being equal.

Second, it seems to further show that an increase in the gliadin ratio is favorable to the production of a better loaf. This, together with the fact that the gliadin number and protein content of these wheats are both relatively low *would seem to indicate that the generally poor quality of these flours is due to a lack of development of glutenin rather than of gliadin.*

Third, the absorptive power in these wheats would seem to have no close relation to the loaf volume, as the loaf volume varies widely in these two groups while the absorptitve power remains essentially the same.

Table No. XX shows that the volume of the loaf is not parallel with the gliadin number. There is shown, however, a somewhat general relation between the volume of the loaf and the percentage loss in the process of baking. This relation is quite constant. The larger the volume of a loaf, the larger the amount of loss in baking and the lighter and whiter the bread becomes. The whiter and lighter loaves have been shown to be the more nutritious than heavier and darker ones. These two characters are very important then, and since the amount of loss in baking is an indication of each, when the comparison is made between breads from similar flours, it is a valuable determination.

The number of loaves of bread of the same size that a flour will yield is a matter of considerable importance and one that is very carefully considered by the bakers. The ordinary housewives would do well to pay some attention to this feature.

In the flours studied this variation ranged from 260 up to 289 one-pound loaves per barrel and in the case of standard 297 loaves per barrel, with a volume as high as 108 cubic inches.

Texture.—The texture of the loaves is seen on cutting them open after they have cooled. In deciding upon this, account is taken of the color of the crust and crumb, the crust should present fine even pores with no roughness or cracks. The crumbs should be uniform throughout as regards evenness and the size of the pores. The body should be moist, soft, and friable. When touched with the finger, it should leave no dent. The membraneous partitions between the pores should be even and thin. In no case should there be any unexpanded masses either glutinous or floury.

In general, the texture of loaves from these flours was poor, not that it was due to insufficient working of the dough or insufficient time in rising, but rather to the quality and quantity of the gluten. In many instances the loaf broke, and in others the crust remained intact but the crumb had not developed evenly. We may say that those flours with less than 5.25 per cent. proteids can not be baked into well-formed loaves under our conditions. Were it attempted to have them raise to the same height in the pan as is common with eastern flours, there would be few that could stand the test.

SEASONAL EFFECT ON CHARACTER OF LOAF.

The following illustration (Figure 18) fairly represents the general difference in the flours as affected by the season as shown in the baking. Nos. 1 and 3 were from the crop of 1904 and Nos. 2 and 4 from the crop of 1905, all the flours of the latter season giving poorer results than those of 1904.

The figures for the loaves are subjoined:

	1904.		1905	
	No. 1 (62a).	No. 3 (19a).	No. 2 (231).	No. 4 (10a).
Total protein	7.97	8.62	8.62	7.08
Gliadin	4.15	4.31	2.33	4.43
Gliadin number	52.0	5.00	39.8	62.6
Volume of loaf	90 cu. in.	92 cu. in.	78 cu. in.	81 cu. in.

FIG. 18.—Showing difference in loaf as affected by season.

Acidity.—The acidity of Californian white wheats is rather low. This may be expected when we remember that the latter part of the growing season is passed in a warm and dry condition, there being no rain to keep the grain green. Then, too, the grain is well matured and perfectly dry by reason of being left standing so long before the harvest can be completed. So there is very little immature or "musty" wheat. The flour contains less fat and less branny portion with foreign particles, thus the chances for fermentation are fewer, and the acidity lower. The determination was made on five grams of flour using one tenth sodium hydrate with phenolphthalein and the result calculated to lactic acid. The range was from .049 to .165 per cent and averaging .095 for all. The following tabulation gives the maximum average, and minimum for the flours from the different wheats.

Kinds of Flours.	Maximum.	Average.	Minimum.
Bluestem	.1086	.0879	.0660
Australian	.1650	.0999	.088
Club	.1485	.0890	.0495
Sonora	.0976	.0945	.088
Average for all		0950	
Standard		.112	

For the purpose of comparing the proximate analysis of the type of wheats with the corresponding flours, those samples which were used for milling and baking tests were subjected to complete analysis and the results are contrasted in the following table:

	Australian.		Bluestem.		Little Club.		Sonora.	
	Wheat.	Flour.	Wheat.	Flour.	Wheat.	Flour.	Wheat.	Flour.
Moisture	10.34	13.24	11.88	13.31	12.03	13.13	12.29	13.77
Ash	1.73	.49	1.69	.47	1.87	.45	1.69	.46
Total protein	8.39	6.73	8.32	6.61	8.31	6.59	7.52	6.39
Crude fiber	2.39	.19	2.78	.09	2.69	.12	2.12	.07
Nitrogen-free extract—								
Fat	1.42	1.00	1.60	.96	1.57	.95	1.41	1.10
Gliadin	2.67	3.34	2.82	3.31	2.94	3.39	2.48	2.78

Ash.—The ash of these wheat flours is very low, averaging .55 per cent. and ranging from a minimum of .32 per cent. in Little Club 253 to a maximum of .72 per cent. in Bluestem 260.

Fat and Fiber.—Both of these groups are so low as to not appreciably affect the flour. The fat averages but .98 per cent. as against 2.24 per cent in Minnesota flours (Minn. Bul. 74, p. 157), and 1.85 for Canadian wheats (Bul. 50, Central Exp. Farm, Ottawa, Canada). This low fat content may explain the high keeping quality of these flours. Certain it is that the Minnesota "Standard" brought from Minnesota at the beginning of these experiments has deteriorated very noticeably within six months, while the native flours do not show any appreciable change.

BRAN, SHORTS, AND LOW GRADE FLOURS.

Bran, shorts, and the low grade flours are the by-products produced in the manufacture of flour. The floury, white content of the grain is the valuable portion. The by-products consist of the fibrous coverings of the kernels, the germ and unavoidable loss of the starch which is removed along with the undesirable parts. The yield of each depends upon the kind and condition of the grain, upon the method of milling and upon the skill of the miller. By improperly supplying the grain to the rolls and manipulating of the streams after bolting, a large amount of flour may find its way into the feed stuffs or some of the feed stuffs may be turned into the flour streams and thus affect not only the color and quality of the flour, but also impair its breadmaking quality and its nutritive value. The bran and shorts are not very different either in the nature of the material or in the composition. In years past, when the flour was not so completely removed, the shorts had considerable more value as a foodstuff than bran, as it contained considerably more of the middlings which the then used process could not reduce, the bran being left in a coarser condition. But the improved methods

have swept away this difference. The shorts is now a little more than finely ground bran with perhaps some ground screening and the sweepings added to it.

The low grade flour is composed largely of the germ parts, the very fine particles of bran and fibrous parts under the bran which are unavoidably obtained in the middlings. To this must be added the very fine specks of dust and hairs of the surface of the grain which were not previously removed, and the small amount of flour that is lost from the chop produced in removing the above débris. The amount thus turned into low grade flour may vary considerably, depending upon the condition of the grain, the process and the kind of flour being produced When milling for a straight grade flour from soft wheat, very little low grade flour need result to make it comparable to eastern straight flours.

In commercial milling, the bran and shorts may amount to 22 or 25 per cent of the grain used and the low grade flour from 2 to 10 per cent, or even more. On a small experimental mill it would be impracticable to get large yields of flour, and it is not necessary in order to obtain comparable results.

The attached Table No. XXI gives the results of the determinations made on the products. While they are comparable among themselves they are lower in every respect with the exception of the proteids, which are higher than they would have been had they been obtained in commercial milling.

TABLE XXI.—SHOWING AVERAGE ANALYSES OF BRAN, SHORTS, AND LOW-GRADE FLOUR FROM WHITE WHEATS.

BRAN.

	Moisture.	Ash.	Total protein.	Fat.*	Fiber.
Bluestem.					
Maximum	13.80	5.71	12.44	2.73	13.11
Average	12.84	5.29	10.39	2.27	11.55
Minimum	11.36	4.73	8.62	2.06	9.76
Club.					
Maximum	13.57	5.90	14.04	2.87	12.03
Average	12.19	5.59	10.73	2.67	10.61
Minimum	8.86	4.97	9.01	2.52	9.44
Australian.					
Maximum	13.53	6.01	15.22	2.53	10.96
Average	12.80	5.29	10.72	2.42	10.17
Minimum	11.86	4.46	7.80	2.29	9.47
Sonora.					
Maximum	12.85	5.20	10.11	----------	--------
Average	12.60	4.82	9.04	2.35	8.41
Minimum	12.33	4.29	7.97	----------	--------

*Determination made on composite sample.

SHORTS.

Bluestem.

Maximum	14.12	4.71	14.91	4.26	7.57
Average	13.22	4.10	11.79	3.99	6.98
Minimum	12.30	3.10	10.03	3.48	6.00

Club.

Maximum	13.99	4.84	14.28	4.51	8.17
Average	12.24	4.25	12.09	4.27	7.49
Minimum	11.29	2.89	9.83	4.06	6.44

Australian.

Maximum	14.02	4.89	16.74	4.35	7.77
Average	12.43	4.31	11.93	4.08	7.05
Minimum	11.51	3.68	8.70	3.71	6.49

Sonora.

Maximum	12.85	5.20	10.11	----------	--------
Average	12.60	4.82	9.04	3.81	5.79
Minimum	12.33	4.29	7.97	----------	--------

LOW-GRADE FLOUR.

Bluestem.

	Moisture.	Ash.	Total protein.	Fat.*	Fiber.
Maximum	14.14	2.47	13.32	2.92	1.86
Average	13.30	1.82	9.63	2.67	1.39
Minimum	11.68	1.25	7.80	2.27	1.07

Club.

Maximum	13.91	2.85	11.80	3.39	2.03
Average	13.01	1.35	9.18	2.82	1.72
Minimum	12.30	1.32	7.08	2.36	1.37

Australian.

Maximum	13.71	2.73	13.56	3.15	2.64
Average	12.88	1.96	10.05	2.70	1.98
Minimum	11.58	1.42	7.97	1.82	1.50

Sonora.

Maximum	13.70	2.14	9.49	----------	--------
Average	13.61	1.86	8.61	3.03	1.67
Minimum	13.52	1.63	7.72	----------	--------

* Determination made on composite sample.

Under shorts, there is a maximum of total protein in the Australian wheats given of 16.74 per cent. This is of interest in that it suggests a wheat with a high protein content. Tracing it back to the wheat we find it has 15.22 per cent in the bran, 13.56 per cent in the low grade flour, 11.72 per cent in the whole wheat and only 7.80 per cent in the flour. This, then, is a case of high protein wheat yielding a flour with a relatively low amount. This suggests the need of looking further than to the nitrogen content of a wheat as indicative of its value for the improving the bread-making quality of the same. This same wheat has also a fair amount of gluten, having 90 per cent. of the total proteids in the form of gluten.

SOME CONCLUSIONS.

(1) The California white wheats have a low nitrogen and protein content.

(2) The larger normal kernels usually carry a higher per cent. of nitrogen than smaller normal kernels of the same type.

(3) The California white wheats are relatively high in fiber and low in ash and ether extract as compared with the hard winter wheats.

(4) The wheat crop of 1905 contained a uniformly lower nitrogen content than did the crop of 1904.

(5) The overlap of gluten nitrogen in the salt soluble extract is represented in the case of white wheat meals by the factor .15 per cent.; for flour .22 per cent.

(6) The polariscopic method for the determination of gliadin has proven very reliable.

(7) The mechanical separation of gluten in the case of this class of wheats is very unsatisfactory.

(8) The California white wheats contain a larger proportion of their total protein in the form of gluten than do most other wheats.

(9) The gliadin-number of these wheats is much lower than for those of the middle west.

(10) These wheats ordinarily produce a very white flour which bakes darker than the tinted flours from winter wheats.

(11) The water absorption of these wheats is relatively low. The white wheat flours absorb about 52 per cent., while the hard spring wheat flours absorb about 58 per cent.

(12) Loaves showing the greater loss in baking, other things being equal, are the lighter and whiter.

(13) Glutens from white wheat flours are not tenacious according as they contain more gliadin.

(14) The gluten of these wheats hydrolyze more than for other types of wheat.

(15) The glutens of these wheats are usually inferior in quality and dull in color.

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1902. Report of the Agricultural Experiment Station for 1898-1901.

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